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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES' EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

DECEMBER 1.

Institute of Metals:—Ordinary meeting at Sheffield. "The Technique of Enamelling," Paper by Sidney Wilkinson.

Institute of British Foundrymen.

DECEMBER 4.

Middlesbrough Branch:—Ordinary meeting. "The Italian Foundry Congress and Some Impressions of Italian Foundries," Lecture by T. Makemson.

DECEMBER 5.

East Midlands Branch (Lincolnshire Section):—Ordinary meeting. "Practical Work in a Jobbing Foundry," Paper by A. Sutcliffe.

Lancashire Branch:—Ordinary meeting at Manchester. "Silicon as an Alloying Element," Paper by J. Arnott.

Custom of the Trade.

Last Saturday we received a letter which reads: "In 1927 we made a segment pattern and corebox of a large chain wheel (7 ft. dia.) and charged our customer on its prime cost only. We have made several castings from this pattern since that date, and our customer has now received a lower price than ours for the supply of these wheels and has requested us to hand the pattern and corebox to him for use in another foundry. Can you advise us what is the common practice of the trade? Our main objection is that we made the pattern and corebox in a manner which may not have occurred to our competitors, and in the construction of which a great deal of time and experience was given to our customers, without cost."

The custom of the trade in this respect is quite clear. Assuming that an order is given for a 1-off job, with little or no chance of a repeat, then the full cost of the pattern is made and there the matter ends. Where, however, repeat orders are expected and only a portion of the real cost of the pattern is charged, then under no circumstances shall the pattern be deemed the property of the customer until the volume of orders received against it has fully reimbursed the supplying foundry for their work. To elaborate this, reference to the die-casting industry is only necessary, whilst, additionally, it should be clearly understood that in invoicing a portion of pattern costs to a customer, many factors are involved, one of the least important of which is the timber in its finished form. Actually, the costs include design, workmanship and overheads, and the buyer has no right to claim the pieces of wood as his share until it is patent to everybody that the founder has been properly reimbursed for his service. As repairs, packing and other incidentals are involved in the despatch of a pattern, most foundries, no matter how long they have used a pattern, make some charge, if the customer requires them to be sent to a competitive foundry. We feel reasonably certain that if our correspondent's customer asked the opinion of their new suppliers (providing this concern possesses a pattern shop) they would most probably get a clear-cut confirmation of our opinion.

Pulverised Fuel.

Engineers commonly acknowledge that pulverised fuel has been under a cloud since the first optimistic accounts of its use were brought from America, and the first installations were made in this country. There is probably no country in the world where it is more dangerous to over-claim special properties for a material or an industrial process than Great Britain, for the inevitable result of the disappointment engendered by failure to come up to the claims is a prejudice which it takes years to eradicate. The result is that only now is pulverised fuel showing signs of coming into its own to any great extent, and the Paper recently read before the London Branch of the Institute of British Foundrymen is very timely. It is particularly difficult to get statements of experience with respect to pulverised fuel from independent parties, and in this connection the Paper is very useful and very comprehensive. It shows very clearly the types of pulverisers available and the nature of the service which they are best likely to perform. It deals with the question of fineness of grinding and with the difficulties introduced by the use of differing coals. One of the greatest snags in the application of foreign furnaces in this country is the very material difference between foreign coals, which are often very friable and easily ground, and British coals, which are much tougher and harder. Furthermore, great differences are found between coals in different parts of the country. Economic considerations may tie a user down to a source of supply with which his plant may not be adapted to deal. The fact of moisture in coal is also very important.

Another subject on which volumes can be written and much remains to be explored, is the central system, in which the whole of the fuel is pulverised in one place and delivered to storage bins or hoppers for use at various furnaces, and the unit system, in which the pulveriser is applied immediately to furnace or boiler requiring the fuel. Here again the decision as to which system is adopted has little or no relation to the technical merits of the system, but to the conditions operating where the pulverised-fuel system is required.

Readers will be interested in the discussion of pulverised fuel applied to metallurgical melting furnaces and annealing ovens, particularly to the new rotary melting furnaces. The life of the refractory material in these furnaces is of very great importance, as is also the type of ash produced by the coal.

Altogether the Paper is one of the most interesting summaries of the pulverised-fuel situation that has been presented for some time.

XUM

Notes from I.B.F. Branches.

Lancashire Branch.—Attention of local members and others who had intended being present at the Branch meeting at the College of Technology on December 5 to hear the Paper by Mr. G. E. Windeler on "Castings from an Engineer's View-Point," is drawn to the fact that as the author is at present in West Africa on business the delivery of his Paper has been postponed until the final meeting of the session on May 7, 1932. Instead, the Paper noted in the syllabus for the latter date, namely, "Silicon as an Alloying Element," will be presented by Mr. J. Arnott, of Glasgow. On this occasion the members of the Manchester Metallurgical Society have been invited to attend, and their President has been asked to open the discussion on behalf of the visitors. Local members of the Institute of Metals have also received notice of the event, which deals chiefly with non-ferrous metal alloys and the recent developments of mechanical and heat-treatment for the purpose of benefiting the physical properties.

The committee arranging the annual dinner of the Branch, to be held on February 6 next at the Grand Hotel, Manchester, have commenced activities, and it has tentatively been proposed that there should be no speeches during the proceedings, but simply the toast of the Institute, to which suitable replies will be called for on the part of the President, Mr. Harley, and the Branch-President, Mr. Roy Stubbs. In this way a much longer period would be available for the ensuing dance. The attention of local members has been drawn to the facilities existing in the district for the special training of juniors for the forthcoming City & Guilds Examinations in foundry work. No less than three Presidents of the Branch are undertaking the supervision of classes in Openshaw and the Manchester College of Technology.

Middlesbrough Branch.—Mr. F. Harris presented his Paper "A Survey of Light-Castings Manufacture," for which he was awarded the 1931 Institute Medal, at a recent meeting of the Middlesbrough Branch. This Paper was published in our issue of February 5, 1931. Mr. A. G. Harrison, Branch-President, presided over a very large audience, which was much interested in Mr. Harris' Paper and in the results of some of the castings which were exhibited.

Scottish Branch.—A meeting was held in Edinburgh on November 21, at the Heriot Watt College, for the purpose of inaugurating a Section of the Institute to cater for Edinburgh and the East of Scotland. Mr. W. Wallace, managing director of Brown Bros. Company, Limited, Edinburgh, presided, and was supported by the President, Vice-Presidents and officials of the Scottish Branch. There was a large attendance of foundrymen from Edinburgh and district, as well as visitors from Falkirk, Paisley, Fife, Bathgate and Glasgow. Mr. Evan Ross, of Messrs. G. & J. Weir, Limited, read a Paper on "Planning for Production," illustrated by lantern slides. Thereafter the objects of the Institute were explained by Messrs. Campion and Campbell, who appealed to the foundrymen of the district to support a local Section.

Mr. A. D. Mackenzie moved that a Section be formed in Edinburgh, and suggested a committee of five with Mr. Wallace as chairman be appointed to manage it. The motion was carried enthusiastically. The President of the Branch, Mr. N. McManus, thanked the local members who had assisted in the arrangement of the meeting, and congratulated them upon its successful issue. He promised the support of members in Glasgow and elsewhere and wished success to the new Section.

A mixture of 98 per cent. water and 2 per cent. flake graphite can be used as a steam-engine cylinder lubricant.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Carbon Pick-Up in the Cupola.

To the Editor of The Foundry Trade Journal.

Sir,—I notice in The Foundry Trade Journal of November 19 a report of the discussion on a Paper given by Mr. J. E. Hurst before the East Midlands Branch of the Institute of British Foundrymen, in which several references are made to carbon pick-up in the cupola. Mr. T. Goodwin says that "carbon pick-up is unrelated to coke quality" and that "founders could disregard the amount of coke placed in the cupola in reference to carbon pick-up." With the first of these statements Mr. Hurst is in definite disagreement, and he does not appear to be entirely sure of the latter. The following figures may be interesting as bearing on this question. They show the total-carbon content of a few blows of iron made with two different quality cokes here just recently. The iron charged, the cupola conditions and the height of bed were in all cases the same. With coke B, a slightly less amount was used between charges, as it had a lower ash content than coke A.

Coke A.—Total-carbon content of Grade I iron, 3.3 per cent. (average of 12 casts); total-carbon content of Grade II iron, 3.2 per cent. (average of 6 casts).

Coke B.—Total-carbon content of Grade I iron, 3.5 per cent. (average of 3 casts); total-carbon content of Grade II iron, 3.4 per cent. (average of 4 casts).

There seems to be no published work on the varying influences of British cokes on carbon pick-up, probably due to a lack of realisation of this effect, and also to lack of proper understanding of the effect of total carbon on shrinkage and porosity.

Mr. W. West recently called attention to this latter effect, and it may be remembered that I lent some specimens illustrating the same thing to the Technical Exhibit of a Foundry Trades Exhibition in London a few years ago. These were cone-shaped castings which had been designed to show the effect of total carbon on shrinkage, and were made during an investigation into the subject which I was following at that time.

It appears, therefore, that from the point of view of getting sound castings, in which I daresay more of us are interested than in unusually high-strength values which appear at present to be the focus of iron-foundry metallurgy, there is a good case for carrying out research on a large scale into the properties of iron-foundry cokes.—Yours, etc.,

H. C. Dews.

Dewrance & Company,
165, Great Dover Street,
London S.E.1.
November 23, 1931.

T.S.M.V. "Polyphemus."—The marine oil-engine installed on this ship has been the subject of the Sixth Report of a Committee of the Institutions of Mechanical Engineers and of Naval Architects. The Report was presented last Friday night. The cylinder valves, seats and piston rings were made of Perlit iron, the last name stated to have been hammered.

The National Union of Commercial Travellers, 24, Thavies Inn, Holborn Circus, E.C.1, has sent us a copy of their 1932 Diary. This contains a good deal of information of special interest to commercial travellers, much of which cannot be obtained in any other diary, particularly the pages on law affecting commercial travellers and agents, and employment hints. Copies of the Diary can be had by non-members of the Union, 1s. 8d. post free.

Random Shots.

"Marksman," packing tooth-brush, notebook and pencil over the week-end, boarded a north-bound express to Bolton, there to interview Mr. Copehendrag, proprietor of Copehendrag's Bijou Jobbing Foundry, who stands to win at least £3 billion in the Killarney Sweepstake. (By the way, anyone interested in founding in the dim ages should make a point of visiting Copehendrag's foundry—the lay-out is reminiscent of the Hampton Court Maze.) "Now, Mr. Copehendrag"—with a flourish of luggage (excluding tooth-brush)—"of course, you've not yet had time to awake to your good fortune. I know that your plans are not settled. But I have no doubt you will sell this foundry—you might even present it to the nation or your worst enemy. You will fly the smoky sordidness of your present environment. Days of honeyed luxury will heal the terrible lacerations that foundry work has inflicted upon your fine intellect. You will buy a yacht, aha? A town house and a country seat? Or perhaps the meridional climes will draw you—the Riviera, Italy, the South of France—playgrounds of eternal youth. . . . But tell me, what do you intend doing with the mass of this vast fortune? You will invest it in industry?" Said Mr. Copehendrag: "Well, Ah've bin thinkin'. Ah'm goin' t' take big chance. Ah'm goin' t' buy pulley hoist block for t' handle castin's in foundry."

* * *

There will always be certain individuals whose activities provide grist for the columnist's mill. I personally acknowledge an incalculable debt of gratitude to Miss Nelly Snookers, fearless leader of original thought, whose foundry at Eastbourne so often is mistaken for the Grand Hotel. Miss Snookers' investigation into that important foundry problem of air cores is progressing. If it continues to progress the sand core will soon find its last resting-place behind museum glass. I shall mourn the sand core; for, though not a core-oil manufacturer, I have a warm affection for it. But progress, if it is to ditto, must march on even over the bodies of starved core-gum compounders. Such are the unalterable laws of ethics!

* * *

Now, the aim of the Gayway research is simply to enclose cores of air in thin sheet-rubber containers, the latter, when the casting is dressed, being removed by a feather duster. Think of the labour, the expense, the material which will be eliminated by the air core! The research is in an early stage still, and the immediate obstacle to success is that the molten metal tends to penetrate the containers and so distort the core. However, doubtless the solution is but the matter of a few days.

* * *

A point of detail I might mention here which serves to illustrate the countless phenomena operating against any research worker. Miss Snookers, noting that the long finger-nails of the coremakers often punctured the containers, instructed the men to cut their finger-nails very short. But then the complaint was made that they were unable to dress in the mornings because of their inability to button up various garments. Miss Snookers supplied a remedy in the form of clothes with lightning metal fasteners. And now Gerald, who is Gayway's most skilful coremaker, is threatening to leave because the fastener on his winter woolly vest is making his chest raw.

* * *

Extract from Correspondence.—"What is the Italian cloak-room ticket joke? It looks as if the publicity had been provided by the party who had the ticket all the time!"

Marksman.

Making Large Steel Saddle Castings.*

By Sidney G. Koon.

Eight cast-steel saddles, a total of 32 huge steel castings, carry the four 36-in. cables over the two 640-ft. towers of the new Hudson River bridge at New York. Each saddle weighs about 150 tons, the largest of its four castings being some 50 tons and the smallest 30 tons.

These castings were made and machined by the Midvale Company, Nicetown, Philadelphia. Acting under instructions of the Port of New York Authority, they were despatched in such manner that each truck—carrying one casting—could be run at once upon the float which was to take it to the base of its tower. Here the casting was picked up by the 200-ton crane mounted on the tower and quickly put in place. The last trainload arrived so closely to schedule that the cars were shunted, one by one, upon the barge—the first one at the instant of arrival, without one minute's delay.

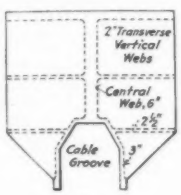


FIG. 1.

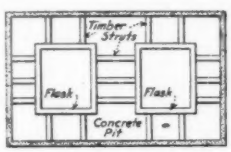


FIG. 2.

Fig. 1 gives an idea of the saddle-casting cross-section, showing considerable variation in metal thickness, whilst the arrangement of the flasks in the concrete pit, and the method of supporting them by struts against distortion, are seen in Fig. 2.

In the eyes of officials of a plant accustomed to work of this magnitude, this was simply "another job," a bit "fussy," perhaps, but all in the day's work. But those of us to whom anything of this great size is always impressive find much of interest in the methods by which such "another job" is undertaken.

Generally speaking, there were two main problems to be solved. One was the successful casting of these great masses of steel in such manner as to avoid flaws at any point. The other was the machining of the castings to exceptionally

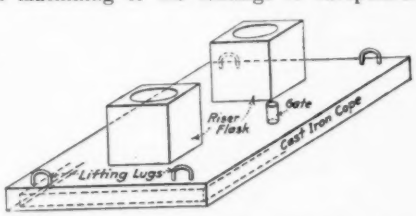


FIG. 3.—REPRESENTING THE CAST-IRON COPE WHICH CONSIDERABLY REDUCED THE MOULDING TIME.

close tolerances for such massive work. The first accomplishment is briefly described below.

Preparations for Making the Castings.

Unusual care was taken in preparing a foundation, such that there should be no possible settlement at time of casting. Five sites were available for the work, four in the steel foundry proper and the fifth in an adjoining building reachable by the open-hearth pouring crane. This latter position has a concrete pit large enough for one of the smaller flasks.

In the steel foundry two flasks, for the largest castings, were placed in a single large concrete pit, 25 by 40 ft. by 23 ft. deep. Space for a flask for the smaller castings was found at the end of a core pit nearby. The fourth location here was made by digging a deep hole in the floor, large enough for a flask, and lining its hard-packed sides with heavy timbers to take the side thrust, of which more later.

* From "The Iron Age," November 5, 1931.

Having built up a flask in this manner, a load of 180 tons was placed upon it to make sure that it was bedded properly and that there would be no future movement. The height, from bottom of casting to top of the risers, was 17 ft. About 18 in. of sand was then rammed, hard, in the bottom of the flask as a bed for the pattern. Coke and ashes for vents were used here, as judgment dictated. Then the pattern was set, upside down with regard to the future use of the casting, and sand was rammed as hard around it as the air rammers could set it. About 2 in. of

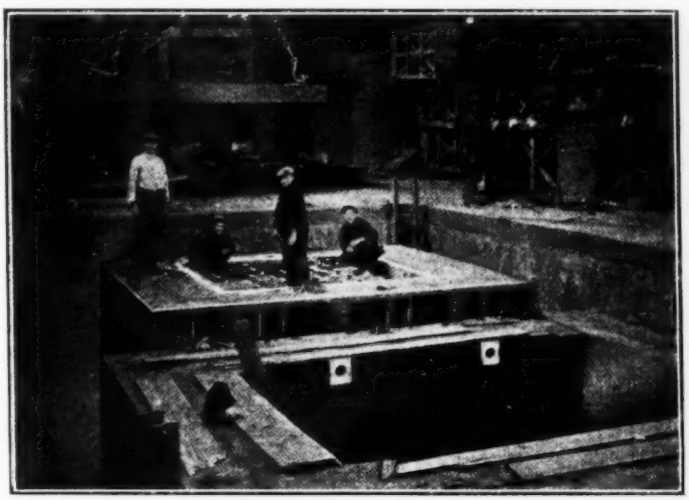


FIG. 4.—TWO MOULDS IN THE CONCRETE PIT. THE MEN ARE SETTING CHAPLETS.

Illustrative of the way the sites were prepared is that of the large concrete pit. About 1 ft. of moulding sand was put in the bottom and rammed as hard as could be done. This was followed by several inches of loose sand, which then was scraped level with a long straight-edge. On this a heavy steel bottom plate, 2½ in. thick, was placed, and the flask, in cast-steel sections, bolted on in layers, as shown in Fig. 2. Two lowest layers had been bolted on before the bottom plate was lowered into the pit. These flask sections are of a standard pattern, 30 to 72 in. long, and 24 in. high. They are 2½ in. thick, heavily ribbed, and are joined by 1¾-in. vertical bolts and 2-in. horizontal bolts.

facing sand was used, the rest being backing sand suitably tempered. This use of backing sand from previous castings saved a large amount of handling.

For the cope a box-form of cast iron was made, as shown in Fig. 3. This measured, for the larger castings, about 10 by 12 ft. and was 12 in. deep with 3-in. flanges and 3-in. flat surface. Its weight was about 11 tons. Two holes were left for risers, well reinforced by peripheral flanges. Sand was rammed hard in this—in what was to be the under side—and held in place by a liberal use of prickers. This device is said to have saved a large amount of moulding work. On top were placed two steel flasks to contain the risers.

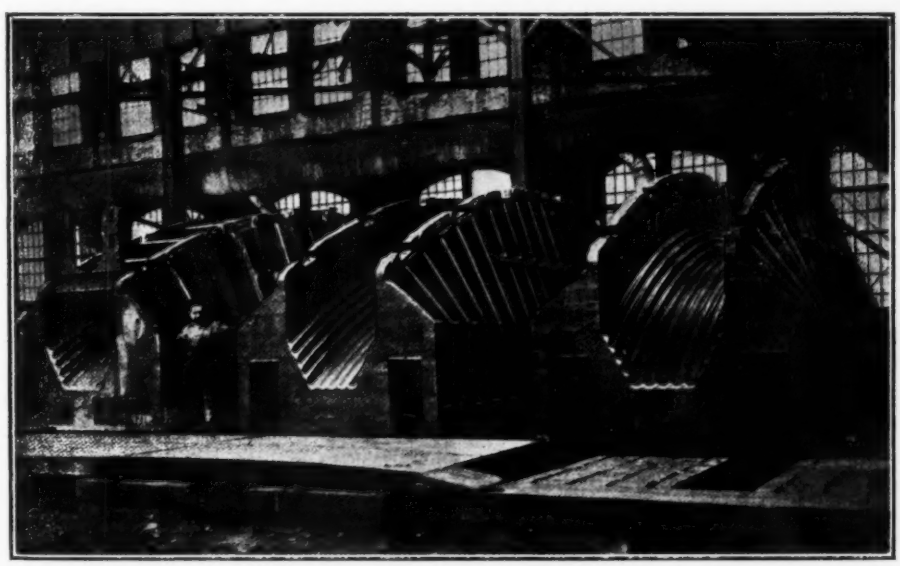


FIG. 5.—THREE OF THE CAST-STEEL SADDLES, COMPLETELY MACHINED.

18 by 30 in. for the smaller castings and 24 by 36 in. for the largest, in each case being 36 in. high.

Before the cores were set and the cope was put in place the mould was thoroughly dried by fires of coke and coal, in baskets lowered into place. The sides then received a silica wash.

Pouring was through a 4-in. runner-brick gate leading to four openings into the mould, two at top and two near the bottom. Fig. 4, in which chaplets are being set above the cores in one mould, shows the two upper gates in the far side of the other mould, nearest the camera.

Each casting was made from one ladle of metal from one open-hearth furnace. Nominally of 50 tons capacity, these furnaces frequently are charged to a total of 70 or 75 tons. For these castings the weight of metal was about 73 tons in the largest moulds, and 44 tons in the smallest. Pouring was from a full-open nozzle until the metal was about halfway up the risers. Then a sprinkling of graphite was thrown over each riser and a slow feeding of metal—a little to one riser and then to the other—was kept up until the risers were full.

Because of the design of these castings some misgivings were felt at first as to the matter of shrinkage strains. As shown in Fig. 1, the central rib, directly under the cable groove, where the greatest thrust of the cable would come in service, is about 6 in. thick. But the envelope making contact with the cable is only 3 in., the horizontal ribs running lengthwise of the cable 2½ in. and the vertical cross ribs 2 in. thick.

To keep the cope from "floating," the riser boxes were bolted down to the flask. They obviated any necessity for placing weights on the cope, for they transferred all "buoyancy" to the entire weight of flask, sand and casting and effectually prevented movement.

Holding the Metal in its Place.

Side thrust from the molten metal, in a casting of the size of those here described, is enormous. At the bottom, with a 17-ft. head of metal, the pressure reaches 7,600 lbs. per sq. ft. To absorb this thrust each flask was surrounded by heavy timber struts, as shown in Fig. 2. These were wedged in place in such manner as to transmit the thrust to the concrete (or other) walls of the pit, backed up, as these walls are, by hard-packed earth. In the largest pit, shown in Fig. 2, one set of struts was placed from one flask to its mate. All struts were wedged tightly to their work.

Each casting was left in the sand for five or six days, before the risers were burned off. While still hot, it was then dug out of the sand, given a rough sand-blast and then run into an annealing furnace before getting cold. Here it was brought slowly up to 895 deg. C.—a "light heat," to prevent cracking when cooling. It was left five days in the furnace to cool, after heat was turned off.

Cleaning these castings was a particularly "special" job, because of the rigid inspection. Every speck of sand had to be removed from every inch of surface, including the ribs, in the search for incipient cracks. Consequently, each casting received almost a grind finish over all surfaces. As the pockets between ribs are only 14 in. wide and reach in some cases to about 6 ft. in depth, the arduous nature of this cleaning will be appreciated.

Inspection after Final Anneal.

A final anneal for five days, again at 895 deg. C., was followed by complete descaling. This, again, involved going over every inch of surface. Once more the inspectors made careful search for cracks. Then the numerous test-pieces were cut off and subjected to physical tests. Chemically, these castings are of plain carbon steel, having about 0.25 per cent. carbon and 0.50 to 0.60 per cent. manganese. Drillings made after final annealing furnished a check in this respect upon the customary ladle analysis of the metal.

In making an exact fit, it was of course essential that the shrinkage on all four castings of each set to be identical, or as closely so as it was possible to obtain. This was achieved in part by getting an analysis of steel so closely to specifications as to leave no room for variance in its shrinkage qualities. But the main consideration here was temperature. Pouring at 1,650 deg. C., each pour was started at the same point as each other pour, to obtain the desired result.

It need not be assumed that all of this procedure and schedule of manufacture grew overnight. Much was learned as the work progressed. In particular, short cuts in the time element were discovered which made it possible to speed up a great deal of the preparatory work. Near the end of the programme castings were being turned out on a regular schedule of a set of five every two weeks.

Synchronous Motor Drives in the Foundry.

By "Kilowatt."

Until a comparatively short time ago the application of synchronous motors was limited largely to high-speed drives, where the driven machines were started without load. Later, low-speed, synchronous motors were used for connection through a suitable clutching mechanism to the load. During the last fifteen years, however, improvements have been effected in the starting and operating characteristics, simplicity and reliability of synchronous motors, and the control has been made more simple and flexible. These developments have resulted in broadening the field of application of the synchronous motor, and now it is used on many applications in place of the induction motor.

The advantages of synchronous motors at speeds of 600 r.p.m. and above are derived to a great extent from applications requiring one or more of such features as power-factor improvement, highest obtainable efficiencies, constant speed, or operation for long periods at partial loads. Of these, power-factor correction is the most common of all reasons for installing high-speed, synchronous motors. Generally, squirrel-cage motors, rated at 250 h.p. and smaller, at 600 r.p.m. and up, with manually-operated starting compensators, are less expensive than unity-power-factor synchronous motors of the same rating with the necessary direct-current exciters and reduced-voltage manual starters. Because of the difference in price of the high-speed motors within these limits, the squirrel-cage induction motor may be chosen to advantage in most instances where power-factor correction is not required, especially if a squirrel-cage motor of the highest satisfactory speed is selected so that it will operate at rated full load.

High-speed induction motors operate at comparatively high efficiencies and power factor when under full load. However, power factors are much lower at low speeds than at high speeds and, likewise, the efficiencies decrease with the speed ratings. Another factor is that the starting torque of a squirrel-cage motor decreases with the speed ratings. These characteristics of low-speed induction motors and the comparable first cost of synchronous motors, in most cases, warrant the use of the latter type for driving direct-connected, low-speed machinery.

The principal advantages of synchronous motors for operating foundry plant are, in general, for both high- and low-speed applications: power-factor correction, higher efficiencies, and constant speed irrespective of load conditions and starting torques comparable with squirrel-cage induction motors. In addition, these motors are available for practically any commercial application, and they are recommended for automatic starting by means of inexpensive, simple and reliable across-the-line type, full-voltage push-button starter. They are especially adapted for direct connection to the load; they require minimum floor space; they are comparable in cost with high-speed induction motors and the required speed-reducing drive for application to low-speed machinery. They are subject to lower maintenance expense than a high-speed motor and the required speed-reducing devices, and are less expensive than an induction motor of equal horse-power and speed rating.

Certain inherent characteristics of synchronous motors make possible a most economical and satisfactory design in speeds ranging from 1,800 r.p.m. down to 72 r.p.m. Induction motors, however, below 600 r.p.m. suffer a handicap in performance because of design limitations, and, for this reason, when driving slow-speed machines, high-speed motors are used with mechanical speed-reducing mechanisms such as belts, chains or gears.

Elimination of all forms of mechanical speed reducers is constantly sought by engineers, as the elimination of every possible step in the conversion of power in their plants means the elimination of possible causes of maintenance expense and interference with continuous production. Power losses in mechanical speed-reducing mechanisms vary from 2 to 15 per cent. or more of the total power transmitted. Directly-coupled synchronous motors avoid these losses.

Maintenance of high power factor results in appreciable economies in the generation, transmission and transformation of electric power as compared with operation on a low, lagging, power factor. Induction motors always operate at a lagging power factor, which becomes excessive at speeds below 600 r.p.m. and at part load. Synchronous motors always operate at unity power factor, which is the most efficient power factor for the operation of an electrical power system, or at a leading power factor to compensate for the lagging power factor of induction motors on the system. Thus the installation of synchronous motors results in raising the power factor. To the user who buys his power this will likely result in a lower power rate as well as a saving in electric-power-transmission losses in his plant and the maintenance of a more constant voltage.

Synchronous motors in their earliest form were awkward and difficult to control. These objections have been removed, however, and the modern synchronous motor is a rugged machine that can be installed anywhere in the plant and operated by unskilled attendants, and that will give the same continuous service, low maintenance expense, and long life that can be realised with the best induction motors.

The widespread use of synchronous motors in industry dates from the time these motors were provided with squirrel-cage windings in the pole faces for starting and were thus able to start and accelerate to full speed with at least a part of their full load. Even with the use of a starting winding, early synchronous motors were built from alternator designs to secure manufacturing economies and, as a result, the advantages of a design for best synchronous motor characteristics were not realised. Torques now available in the modern synchronous motors have been largely responsible for a greatly enlarged market for this type of motor. There are many applications that are now best driven by synchronous motors which were considered totally unsuited a few years ago. The elimination of the need for clutches and the simplification of control made possible by full-voltage starting have done a great deal to popularise the use of synchronous motors.

Closely allied with starting and pull-in torques, in synchronous-motor design is starting k.v.a. This varies from approximately 200 per cent. to 250 per cent. for motors for low-speed compressors and similar applications started on full voltage to several times this amount for applications requiring very high starting and pull-in torques.

XUM

High-Strength Sand-Casting Aluminium Alloys.*

By W. C. Devereux.

The subject will be confined to those alloys now used extensively for highly-stressed or special parts, such as "Y" alloy, the R.R. alloys, and the 4 per cent. copper alloys used widely in America. At no time in the history of non-ferrous alloys has any one alloy progressed and been used so extensively in such a short time from its first appearance as has the R.R. range. It must be borne in mind, however, that these alloys were, in their experimental days, subject to investigation and research by a firm which has a world-wide reputation for the thoroughness with which it conducts its investigation before being satisfied and incorporating a change in its products. The R.R. alloys were not marketed for years after the first conception, and have been subjected to every form of test for the application they are essentially designed for, namely, aircraft construction, and no greater test could be put to any material.

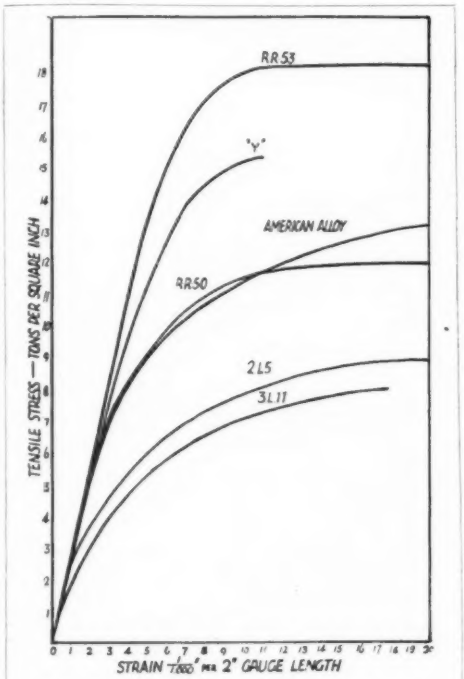


Fig. 1.—Stress-Strain Diagrams for Sand-Cast Alloys.

Alloy.	Limit of proportionality.	0.1 per cent proof stress.	Y.P.	Ultimate stress.	Brinell.	Elongation on 2 in., per cent
R.R.50, heat-treated ..	6.5	10.0	11.0	12.8	76	3
R.R.53, heat-treated ..	14.0	17.5	—	18.4	134	1
American alloy, heat-treated ..	6.0	9.5	12.0	13.6	85	2
"Y" alloy, heat-treated ..	7.5	14.0	—	15.5	121	0.5
2L5 ..	2.5	5.6	7.5	10.6	75	2.5
3L11 ..	2.0	3.8	—	8.8	50	1

All stresses in tons per sq. in.

The British are fortunate in having in this country designers—particularly in the aircraft industry—who are not content merely to judge a cast material on its separately-cast test-piece values. It is recognised generally that a material which is rigid, high in creep resistance, and has good casting qualities, ensuring castings free from local cracks, porosity and draws, and not subject to weakness due to hot-shortness or shrinkage, is much to be preferred to one having better physical properties in the test-bar but subject in some degree to the defects enumerated; in other words, it is useless making a casting with good test-bar results if the casting itself has a local weakness.

Competition from Drop Forgings.

The use of a chill-cast test-piece as used in England in aluminium castings is a very good comparative test of the consistent quality of a material, although being no measure even in physical properties as to the superiority of one alloy over another, insomuch that one alloy may need perhaps an entirely different method of feeding from another; therefore the test is only comparative for the actual alloy under test. The chill-cast test-bar, and indeed the separately-cast bar serves a useful purpose, but it is felt that its use has been responsible for an attitude in some foundries of aiming for good test results to the neglect of the actual casting, and that development has been along the lines of obtaining good test-pieces to the detriment generally of developing the best method of casting. The inconsistency of the castings as a result of this policy is one of the important factors which has led to the supplanting of castings in many cases by forgings, especially with aluminium alloys. The enormous improvement in modern machine tools, combined with the ease with which aluminium alloys are machined, not to mention the ingenuity of the production engineer, has assisted the competition of forging with casting. It is not so much because the casting, made correctly and consistently, would not satisfy the demand of the designers—they very often would—but in the aircraft industry so much difficulty has been experienced in obtaining such castings that to ensure continuity of production firms have been forced into the use of forgings where they would never have gone to the development for other reasons. Having taken this step they find that however difficult the shape of the part, the manufacture is not so formidable, made as a forging, as was supposed, and they have the assurance that practically every forging entering into the receiving department can be counted on as producing a finished part.

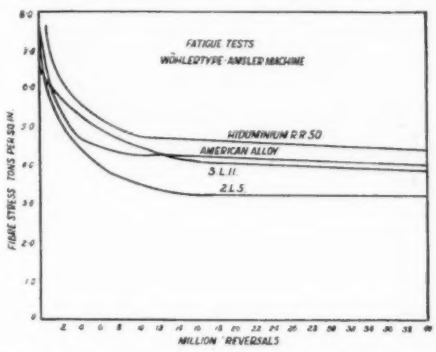


Fig. 2.—Fatigue-Test Curves of Sand-Cast Alloys.

Table I.—*Percentage Composition of Casting Alloys (Remainder Aluminium).*

Alloy.	Cu.	Ni.	Mg.	Ti.	Fe.	Si.
R.R. 50 ..	1.2	1.3	0.1	0.18	1.1	2.2
R.R. 53 ..	2.2	1.3	1.6	0.08	1.4	1.2
"Y" alloy	4.0	2.0	1.5	—	0.3	0.3
American alloy ..	4.0	—	—	—	0.6	0.8

Casting Properties and Elimination of Chills.

It is vital, therefore, that in deciding on materials a founder should decide on those that respond well in the foundry, and should study most closely the correct method of casting to obtain consistent qualities throughout the casting. The more the elimination of chills can be brought about in the casting of aluminium alloys, the sooner will this be obtained.

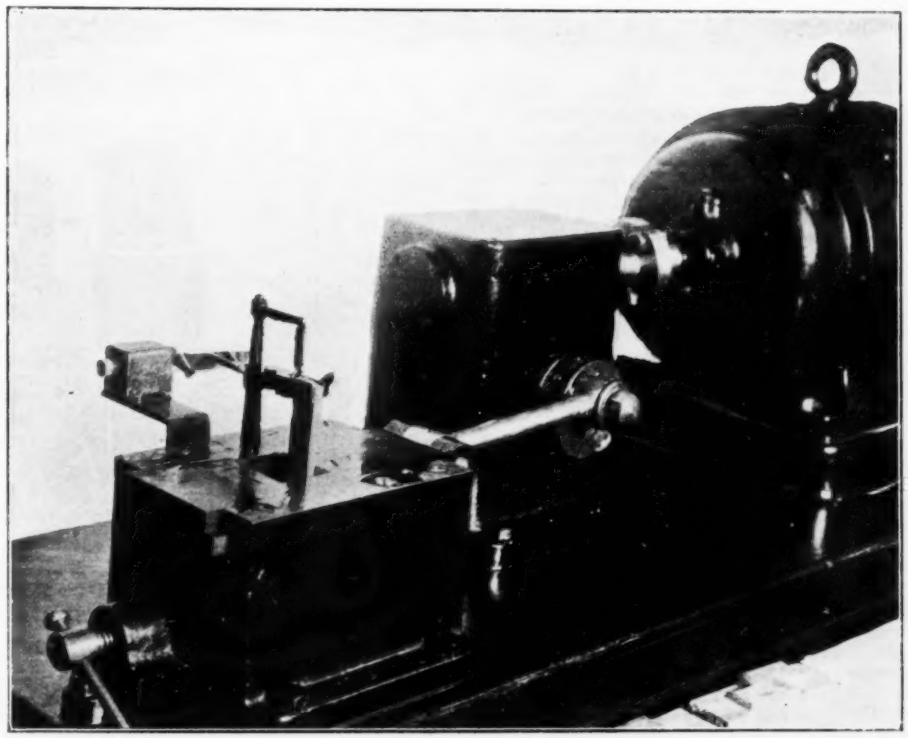


Fig. 3.—A Machine Designed for Ascertaining "Deflection Fatigue."

* A Paper read before the Scottish Branch of the Institute of British Foundrymen, Mr. N. McManus presiding.

Most founders are familiar with the specification of analysis of the various materials under discussion, but for completion they have been set out in Tables I and II. Letters patent have been issued covering the R.R. range of alloys, their manufacture and heat-treatment, the numbers being 281,912, 292,407, 300,078, 312,555, etc.

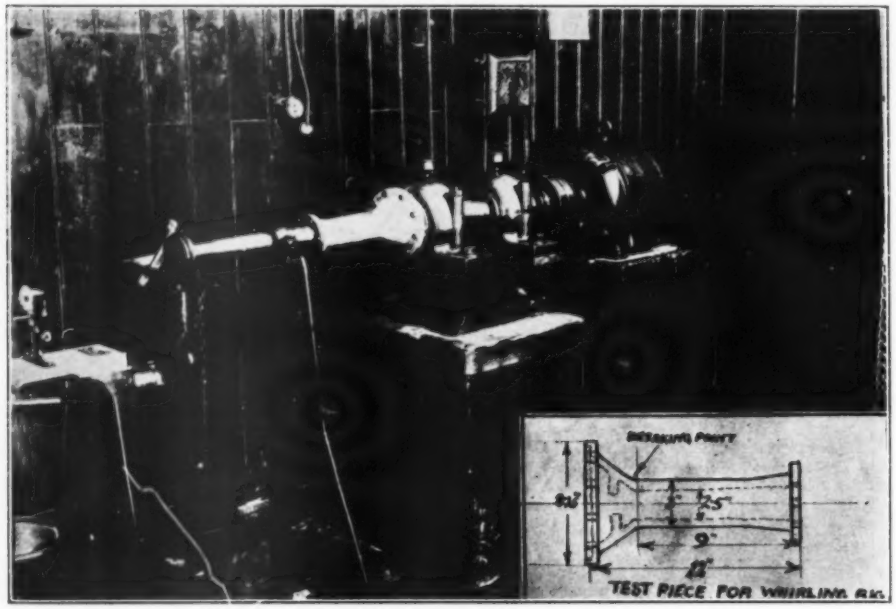


Fig. 4.—A Machine for Testing Fatigue by Rotation.

Table II.—*Heat-Treatment of Casting Alloys.*

Alloy.	Solution treatment.			Precipitation treatment.		
	Temperature.	Time.	Quench.	Temperature.	Time.	Quench.
	Deg. C.	Hrs.		Deg. C.	Hrs.	
R.R. 50	—	—	—	170	20	Cold water.
R.R. 53	530	2	Cold water	170	20	Cold water.
"Y" alloy	520	2	Boiling water	5 days' natural ageing at air temperature.		
American alloy	520	12	,,	160	20	Water.

Mechanical Properties of Light Alloys.

Table I shows the chemical analysis of the alloys, whilst Fig. 1 gives stress-strain diagrams, the sand-cast test-bars being cast to shape, the parallel portion 0.60 in. dia. machined to 0.564 in. dia. The tests are taken in the condition in which the material is recommended for use, and Table II gives the heat-treatment to which the alloy has been subjected.

Fatigue tests have been conducted on an Amsler-Wohler type machine, and Fig. 2 gives the curves, including those of some of the older alloys. The test-pieces are sand cast 1 in. dia. by 9 in. long, turned to 0.53 in. dia. at the maximum bending moment.

An interesting test has been made on the machine shown in Fig. 3, which may be designated deflection fatigue; the machine is run slowly at 42 reversals per min., the test-piece being sand cast near to shape and machined all over. The figures obtained are shown in Table III.

What is illuminating in this test is the influence of work hardening on the high-copper alloys, as demonstrated by the increase of the elastic limit denoted by the larger number of reversals at the small deflection; this work hardening not having time to occur at the higher deflections, where immediately the elastic limit is exceeded. Likewise this test shows the advantage of a material having the higher elastic limit and the ability to resist work hardening, as do the R.R. alloys. In this connection it is interesting to compare the statement of Ludwick before the New International Association for Testing Materials at Zürich in September of this year. He states: "The resistance to alternating stress showed itself to be dependent chiefly on the resistance to deformation and to cleavage, but not to the ability to undergo deformation."

Tests were conducted on a machine shown in Fig. 4. The test is rather a good comparative fatigue test of actual sand-cast specimens. The sketch in the corner of the figure gives the actual size of the test-pieces. Tests are taken on six castings of each material, the average figures being given in Table IV. The machine is rotated at 1,420 r.p.m. and is run with a load of 200 lbs. for 10 hrs., the load then being increased every 2 hrs. by 20 lbs., until fracture occurs. The alloys of "Y" alloy and R.R. 53 are largely used in the chill-cast state, possibly the most use being made of these two alloys in the form of pistons. The physical properties of these alloys are therefore given in the chill-cast state. The influence of the type of chill is very noticeable, as will be seen when considering the two types of chill moulds shown in Fig. 5, and for purposes of comparison the tests shown in Table V have been included.

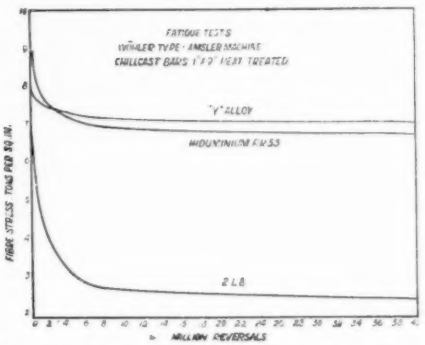


Fig. 6.—Fatigue-Test Curves of Chill-Cast Alloys.

Solidification Range and Soundness.

It is remarkable that those alloys having a prolonged solidification range respond better in the plain type of mould, as compared to the mould with heavy feeders, than the alloys having a more eutectic composition. This is probably the reason why, in casting R.R. 50, one needs to use larger runners, risers and shrinkage pads, dispensing with the use of chills to a large extent. Note, for instance, the improvement with feeding of the 2L5 and R.R. 50 alloy, and compare this with "Y" alloy; then compare the melting curves of these two alloys in Fig. 13 with "Y" alloy in Fig. 14.

Another interesting point is the effect of the mould on the 0.1 per cent. proof stress, and the comparison of these figures with the proof stress of the sand-cast test-piece. Undoubtedly the reason for the seeming anomaly between the proof stress in the straight mould without feeder, and the sand-cast test-piece in the R.R. 50 alloy,

Fig. 5.—Standard Chill Moulds for Test-Pieces.

is explained that the solidification of the material is more rapid, and the material in the B.E.S.A. mould is not fed as it should be, and as it would be in any die-cast application or in the other mould. Obviously then, the core has a certain weakness, which would result in a lowered proof-stress value. The ultimate stress would be assisted by the good chilling of the outside portion of the test-piece. The reason for the

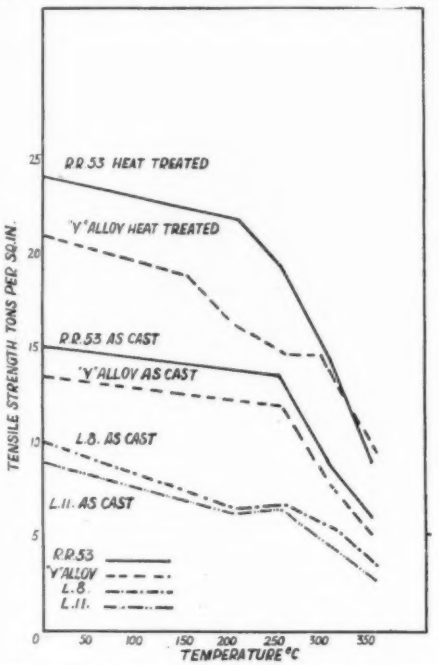


FIG. 7.—EFFECT OF TEMPERATURE ON THE TENSILE STRENGTH OF VARIOUS ALUMINIUM ALLOYS.

necessity of feeding to obtain the best results can be seen. The fatigue curves of "Y" and R.R. 53 in the chill-cast state are given in Fig. 6 as compared with L. 8 chill-cast, the test-piece being cast in 1-in. dia. chills and heat-treated. The curves of "Y" alloy and R.R. 53 are seen to cross at about 7.5 tons per sq. in. This is due to the higher 0.1 per cent. proof stress of R.R. 53 allowing a greater number of reversals at the heavier stresses, thus showing R.R. 53 to be the more suitable material where periodic severe overloading is at all likely to occur. As the "Y" alloy and R.R. 53 are used mostly for pistons and sand-cast cylinder-heads, or for parts subject to work at elevated temperatures, the chart, Fig. 7, giving the effect of temperature on the tensile strength, may be interesting, whilst chart Fig. 8 gives the effect of temperature on the Brinell hardness. The tests have been taken on 1-in. dia. chill-cast test-bars, cast in accordance with the B.E.S.A. specification, and the tests taken at the various temperatures after holding the test-piece at the temperature for 30 min. Fig. 9 shows a sketch of the furnace used, the Brinell-hardness figure being taken by holding the test-piece at temperature in a bath of oil heated and held at temperature for 30 min., the test being taken at the temperature.

TABLE III.—*Deflection Fatigue Results on Sand-Cast Alloys.*

Deflection.		R.R. 50.	R.R. 53.	"Y" alloy.	2L5.	3L11.	195.	195.
Distance from vertical.	Total angle.	H.T.	H.T.	H.T.	As-Cast.	As-cast.	4 hrs. at 520° C.	12 hrs. 520° C. 20 hrs. 170° C.
$\frac{1}{16}$ in.	2° 20″	39,270	102,354	113,492	45,598	60,768	57,826	118,764
$\frac{3}{32}$ in.	3° 30″	6,312	16,766	10,540	5,678	2,028	7,328	15,446
$\frac{1}{8}$ in.	4° 40″	766	1,670	920	428	300	364	1,514

Wear and Friction Properties.

Before proceeding to the actual casting qualities of the materials, it is proposed to complete what one may call physical tests with rather an unusual test on a machine installed in the Rolls-Royce laboratory. It is an attempt to measure

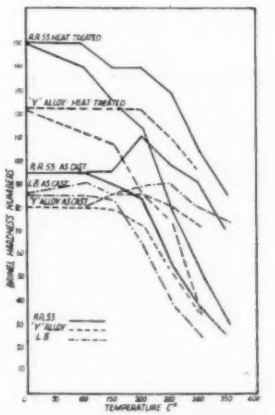


FIG. 8.—EFFECT OF TEMPERATURE ON THE BRINELL HARDNESS OF VARIOUS ALUMINIUM ALLOYS.

the wear and friction properties of the material to be used for pistons. The machine is shown in Fig. 10. The four test-pieces are held in a chuck, shown on the table. This is rotated through a swivel joint from the spindle directly connected to the motor. The discs run in a bath of P. 4 oil against a steel disc of 0.5 per cent. carbon steel (B.E.S.A. S. 70). The oil is heated over the range up to 200 deg. C. The disc is loaded to 100 lbs. per sq. in. and runs at 545 r.p.m. Amperes give the measure of relative friction. Fig. 11 is a chart of the results of this test on various materials, whilst Table VI gives other essential characteristics.

TABLE IV.—*Whirling Rig Test Results.*

Material.	Average ultimate load, lbs.	Total hours run.	Brinell hardness of specimens.	Condition.
R.R. 50 ..	590	48¾	80	Heat-treated.
2L5 ..	545	43	87	As-cast.
3L11 ..	480	36¼	67	As-cast.
"Y" alloy	490	38	104	Heat-treated.
American alloy ..	480	37	80	Heat-treated.

Casting Properties.

The casting qualities most desirable are low contraction and hot-strength to withstand the stress of contraction on to the cores. The material must be fluid in the mould, and have little skin friction. Invariably, good casting alloys show a large tendency to pipe at the risers, that is, that the smaller the distance of the liquidus from the solidus point, the more the necessity of providing large runners and risers, as from the commencement of crystallisation, a shorter time will there be for the metal to feed before complete solidification, but this is a very desirable feature in providing castings sound, free from porous places, shrinkage cracks and draws, and to the elimination of that curse to consistent results, the use of chills.

TABLE VI.

Alloy.	Specific gravity.	Thermal conductivity. C.G.S. units at 18 deg.C.	Coefficient of linear expansion.		
			20–100 deg. C.	20–200 deg. C.	20–300 deg. C.
R.R. 50 ..	2.73	0.415	22.0	23.1	24.1
R.R. 53 ..	2.73	0.43	22.2	23.3	23.8
"Y" alloy	2.78	0.42	22.0	24.0	25.6
2L5 ..	3.0	0.30	25.5	27.2	28.2
2L8 ..	2.88	0.34	22.4	23.6	28.6
3L11 ..	2.88	0.387	24.6	26.2	28.0
American alloy ..	2.79	0.40	23.2	24.6	26.7

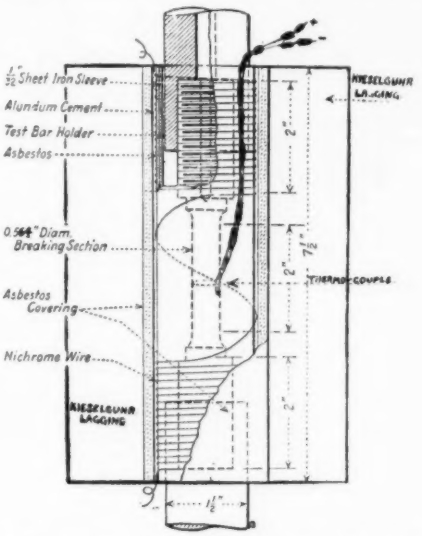


FIG. 9.—HEATING ARRANGEMENT FOR THE ASCERTAINING OF PROPERTIES OF ALLOYS AT ELEVATED TEMPERATURES.

TABLE V.

Alloy.	Type of mould.	0.1 per cent. proof stress. Tons per sq. in.	Ultimate stress. Tons per sq. in.	Elongation. Per cent. on 2 in.	Brinell hardness.
R.R. 50, heat-treated	B.E.S.A. type	8.0	13.6	4.5	80
	R.R. type with feeder head	10.0	16.2	6.5	83
R.R. 53, heat-treated	B.E.S.A. type	19.8	22.0	1.0	140
	R.R. type with feeder head	23.0	25.3	2.5	148
"Y" alloy, heat-treated	B.E.S.A. type	12.5	20.0	3.0	110
	R.R. type with feeder head	12.4	19.0	2.5	114

To give some comparison of the qualities of various alloys, judged from the standpoint of good casting qualities, Table VII gives the linear contraction of the alloys under discussion,

whilst the hot-strength in the mould was tested by placing a tee-shaped pattern in a sand mould allowing contraction on to two steel distance-pieces, as shown in Fig. 12. The test was commenced with the distance-pieces fitting the pattern, and subsequent tests done by machining clearances between the distance-pieces and the pattern, until all materials remained unbroken—of course, the clearance was filled in with sand. Table VIII gives the result of this test.

Fig. 10.—A Machine Designed for Testing the Wear and Friction Properties of Alloys.

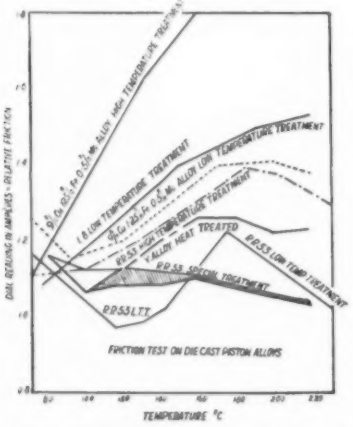


Fig. 11.—Friction-Test Curves of Die-Cast Piston Alloys.

R.R. 53 special is used by the author in the manufacture of exceptionally delicate die castings, such parts as die-cast radial cylinder-heads, etc. The silicon content is brought up to 2 per cent., some sacrifice being made in the ultimate strength and strength at temperature to secure exceptionally good die-casting properties, but the standard R.R. 53 is used for all pistons and other castings, except those that are extremely delicate. The added silicon reduces the ultimate strength after heat-treatment by 2 to 2.5 tons, but the difference is not so much when at the higher temperatures. Fig. 14A shows a number of dilation curves, the characteristic hump in the R.R. 50 curve at the temperature below precipitation low-temperature heat-treatment being outstanding. The heat-treatment desirable for the alloys under discussion has been given in Table II. The great drawback with those alloys needing the high-temperature solution treatment is the difficulty in preventing distortion, cracking and heat-strain set up when dealing with large castings. Probably there is no advantage to be gained by giving a high-temperature treatment to sand-cast alloys. Generally speaking, a sand casting is in a strained condition, as it is stressed in cooling by the resistance of the cores; this strain very often is accentuated by the high-temperature treatment and the subsequent quench. With delicate castings, having abrupt or distinct changes of section, it is necessary to bring up the temperature very gradually and adequately to support the castings in the furnace and during the quenching operation. If using an electric furnace, it should be done in steps to allow of even distribution of the heat in thin or thick sections. All the well-known electric furnace makers will fit an automatic control which will allow of this bringing up in steps, and when the required temperature is reached, will maintain automatically at this temperature. It has been found that the best method is to employ a salt bath, using frozen crushed salt surrounding the work to commence with. In design, to obtain the maximum of service demands an accurate knowledge of the

Fig. 12.—Showing the Method Used for Determining Linear Contraction of Cast Alloys.

Table VII.—*Linear Casting Contraction.*

Alloy.	In. per ft.	Pattern-makers' scale.	Contraction, per cent.
"Y" alloy ..	0.155	1/77	1.29
R.R. 50 ..	0.125	1/96	1.042
R.R. 53 ..	0.140	1/86	1.163
American alloy	0.188	1/64	1.563
2L5	0.154	1/78	1.266
3L11	0.128	1/83	1.205

Table VIII.—*Hot-Shortness Test.*

Clearance.	Materials.							
	R.R. 50.	DTD. 25.	R.R. 53E. Special.	3L11.	R.R. 53.	"Y" alloy.	2L5.	4 per cent. Cu American alloy.
Nil ..	Unbroken	Unbroken	Unbroken	Broken	Broken	Broken	Broken	Broken
1/64 ..	"	"	"	Unbroken	"	"	"	"
2/64 ..	"	"	"	"	Unbroken	Unbroken	Unbroken	Unbroken

XUM

characteristics of the alloy, and how best to employ them.

Achieving Lightness of Section.

The present demand is for lightness. The author is convinced that generally the design of aluminium castings is heavier for their service than need be. In the case of aircraft castings, where lightness must be allied with strength, it is noticeable that those firms having their own foundries have been able to reduce the thickness and weight of castings due principally to the fact that they have been able to see exactly the foundry trouble. Some of them use distinct methods of casting, not only to produce castings of good appearance, but regulating the method of casting, gating, etc., to obtain

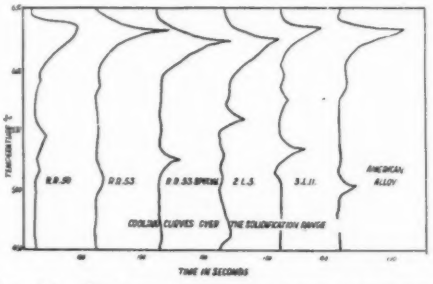


Fig. 13.—Cooling Curves of some Aluminium Alloys over the Solidification Range.

the correct strength in the right place, whereas it has proved more difficult with the detached foundry which is concerned more in making a good-looking casting that will machine clean. Further, the detached foundry, by using the argument of hold-up in production, has been able to influence the design in the way of increasing thickness, radii and other alterations, many of them made at the sacrifice of lightness. What is inferred is, that there has been more co-operation between the foundryman and the designer when both are working for the same

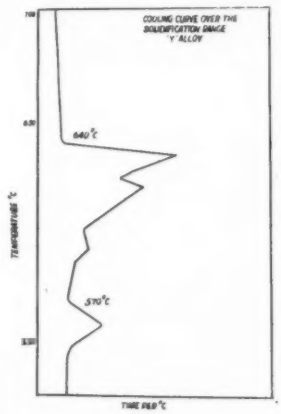


Fig. 14.—Cooling Curve of "Y" Alloy over the Solidification Range.

organisation than when the work is going out to the detached foundries. The attitude of many of the smaller detached foundries has not been conducive to the co-operation that is so essential if the casting industry is to be benefited. There is a distinct trend in aircraft design to move away from castings to the more reliable forging, and the companies manufacturing forgings and stampings are showing more willingness to work with the designer.

Of course, there are outstanding instances of foundries that are doing everything possible to give the designer what he wants, but it is feared that even these large companies have been willing to sacrifice much in the general endeavour to meet the extensive demands in castings for lower prices.

It is probably agreed that the general low scale of prices is in a great measure the fault of the foundry. Obviously, the very low prices now quoted for general and automobile castings can only be obtained by the very large use of secondary or scrap material. Foundries have not exhibited sufficient strength of mind in meeting the demand of the designer and the buyer, and, as is usually the case, any ill-effect will be borne by the foundry eventually.

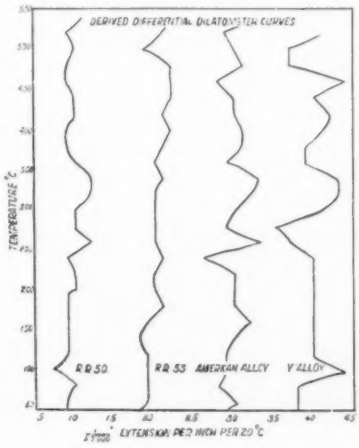


Fig. 14a.—Derived Differential Dilameter Curves of Some Aluminium Alloys.

This apparent transgression from the subject has been made in order, if possible, to stress the importance of every assistance being given to the designer from the foundry. When this is done efficiently, and sufficiently strongly, it is surprising what good results can be obtained.

(To be concluded.)

Catalogues Received.

Sand-Blast Barrels.—The November circular issued by Messrs. J. W. Jackman & Company, Limited, Vulcan Works, Blackfriars Road, Manchester, is devoted to an illustrated description of a new type of sand-blast barrel. It is of particular interest to the non-ferrous founder in a small way of business, who has neither the output nor the capital at his disposal to install an expensive sand-blast equipment. The outstanding features of the apparatus described are that the barrel and the dust-exhaustion arrangement are in one unit, whilst the screen dust filter and fan are built integrally with the barrel. Thus, a self-contained plant, requiring no foundations, has been made available for the cleaning of castings whilst incorporating the complete removal of dust and the discharge of clean air to the surrounding atmosphere. Only 1.5 h.p. is necessary for operating both the barrel and the fan. This plant has been standardised for a particular range of jobs and is made in one size only—in this case a wise procedure, as service is thereby simplified and better value for money can be given.

Electric Motors.—It was a happy thought of Messrs. Higgs Motors, Limited, of Witton, to publish at the moment a 12-page brochure bearing the title of "British Industry," as a much larger percentage of the thought-output of the individual is being given to this subject than normally, in spite of such epoch-making events as the Irish Hospitals' Sweepstake. The brochure is not really political, but it just carries a convincing argument for hard work, which the balance of the book illustrates as being effective in the case of Higgs' own enterprise. It is the proud boast of this company that "during the last 19 years no firm has made greater progress on the manufacture of electric motors than Higgs Motors; the secret of the success is open to all and sundry—hard work." We recommend a perusal of this brochure as a better stimulant than a couple of post-war cocktails.

Retorts.—We have received from the Consett Iron Company, Limited, Consett, County Durham, a folder, mainly devoted to the supply of silica ware for gasworks. We dislike this particular form of publicity, as the recipient of a folder surmises that it is just something to catch the eye, whereas, in fact, it often contains a quantity of quite valuable technical data well worth filing. We suggest that, as so many firms have a file of catalogues, all technical matter should be presented in leaflet or brochure form, but not as folders.

Copper Steel.—Those of our readers who have received a copy of the brochure on Bearco copper-bearing steel, just issued by the Consett Iron Company, Limited, Consett, County Durham, will certainly have noticed its appearance in the morning mail, as its shining copper-decorated cover makes its presence well felt. Having made such a striking *début*, one naturally expects high-grade publicity matter in the interior. This has been well achieved, for its eight pages carry the very convincing message that copper steel is much more immune from corrosion than the ordinary material. Some of the tests detailed will make the foundryman look to his laurels, just at the time when he is making notable progress with the chemical manufacturer. Actually, if we were building a new foundry, we should specify copper steel, as foundry fumes, especially when casting magnesium, can be fairly corrosive. For a foundry to remain spick and span, much money has to be spent periodically on reconditioning the steelwork, a figure we should anticipate reducing by using a comparatively cheap non-corrosive steel such as Bearco.

Cable Boxes.—The Liverpool Electric Cable Company, Limited, Linacre Lane, Bootle, Liverpool, has prepared for distribution a four-page leaflet illustrating and describing a range of cast-iron outdoor inverted cable-end boxes (hooded type) for wall or pole mounting.

Foundry Inaugurates Suggestion Box Prize Scheme.

Messrs. Sidney Flavel & Company, Limited, the well-known Leamington stove and grate manufacturers, are introducing a novel scheme into their establishment, which should prove beneficial to both employers and employees. A competition has been inaugurated—in future to be held monthly—in which all employees are asked to make suggestions for alterations in the works, and the work carried out, which are likely to improve the workers' conditions and the firm's standing. Each employee has received a form for the first of these competitions. No name is used, for the slips are numbered, and the originators of the most practicable and useful proposals will not be known until the final issue is settled. A committee will be formed at the employees' choice to deal with the suggestions, and, if necessary, further advice from the department concerned will be requested on technical matters enclosed in the ideas. Substantial awards will be made to the most successful entrants. The firm is to be congratulated on this enterprise, which will bring about a desirable co-operation between the management and workpeople.

New Russian Iron and Steel Plants.—The first section of the large iron and steel plants which are being erected at Magnitogorsk in the Ural Mountains, and Kuznetzk, in Siberia, was completed recently. Construction was begun in June, 1930. The first of the four blast furnaces, which will have a capacity of 3,500 tons of iron per day, has been put into operation. The total capacity of these plants will be 3,700,000 tons of iron per annum.

American Foundrymen's Association.

PHILADELPHIA CHOSEN AS 1932 CONVENTION CITY.

The Thirty-sixth Annual Convention and Exhibition of the American Foundrymen's Association will be held in Philadelphia from May 2 to 6, 1932. All convention and exhibition activities will be centred in the new Municipal Convention Hall, situated at 34th Street and Vintage Avenue. In this new building, one of the most completely furnished and equipped convention halls in America, provision will be found for adequate exhibit space, with unusual facilities and splendid meeting rooms for all convention sessions, making possible the holding of practically all phases of the convention week under one roof.

Tentative plans for the 1932 programme include a number of practical shop-operation and round-table sessions of the type which proved so popular at the 1931 Chicago Convention that the meeting rooms there were taxed to capacity. The Philadelphia Convention Hall, however, has broad facilities in the way of meeting rooms to fit any requirement of this annual foundry meeting.

The main meeting rooms include the ballroom, with a seating capacity of 1,300; the ballroom extension, seating 300; ballroom balcony, 350; lounge, 350; and restaurant extension, 350. All these rooms can be served from the main dining hall kitchen, which is as modern and completely equipped as any first-class hotel or club kitchen. The main convention hall restaurant is located directly below the hall at the end of the Exhibition Hall.

For exhibition purposes two large, well-lighted and well-ventilated halls are available in the new convention building. These halls are the arena or auditorium and the exhibition hall proper. Complete power facilities are available, including provision for both alternating and direct current, gas, compressed air, hot and cold water and live steam.

The arena, having a seating capacity of 13,200, is built in the form of an amphitheatre with a height of 88 ft. from floor to ceiling and without supporting columns of any kind. The arena stage, which is 116 ft. wide by 56 ft. deep, can either be used for additional exhibits or converted into a meeting room by lowering the steel-asbestos fire curtain with which it is provided.

The exhibition hall, the over-all dimensions of which are 146 by 250 ft., is on the lower floor and conveniently adjacent to the main convention hall restaurant. This restaurant is beautifully panelled in walnut and is unusually accessible to any part of the building.

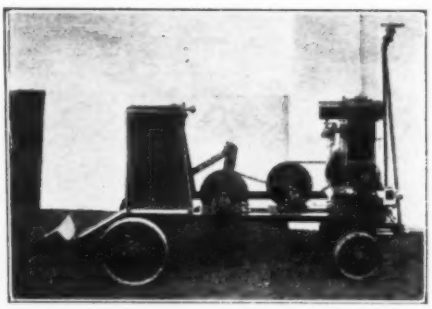
Handling of freight and materials in and out of the convention hall will be provided for economically and exceptionally well. A siding of the Pennsylvania Railroad enters the building itself alongside a receiving platform, all under cover and with the platform on a level with the truck floors. Materials thus can be handled promptly and directly into the exhibition hall, on the same level, or to the arena floor by means of 20-ton elevators.

With such facilities available, the American Foundrymen's Association will be in a better position than ever before successfully to co-ordinate all phases of both exhibit and convention sessions. With a broad technical programme well under way for Papers and reports on interesting and valuable foundry subjects, the 1932 Philadelphia meeting offers exceptional opportunity for a successful and representative convention of the foundry indusry.

Northumberland County Council has accepted the tender of Messrs. Stothert & Pitt, Limited, Bath, at £13,964, for the supply of electrical plant, etc., for the equipment of the Hare Crag Quarry.

The Coleman Mechanical Loader.

In our last issue we gave a brief description of this plant, which we discovered in operation at the "Public Works" Exhibition. From the illustration it will be seen that it is a light, compact and simple machine, which can be shifted around the works for doing odd jobs. As, in its present form, it has only a straight-line throw, it requires a man to feed it; it does not profess to dig. In fact, since the manufacturers claim that when operated by a 2-h.p. petrol engine, such as is shown in our illustration, it will load at the rate of 30 tons per hr.,



The Coleman Mechanical Loader.

we feel that 2 men could be usefully employed in assisting the filling of the scoop, as it makes 64 actions a minute. By adjusting with the wheel shown, the throw can be regulated. We think that one of the first applications of this machine should be that of a testing machine for shovel blades. If we were a shovel manufacturer, we should certainly put one to use for the ascertainment of "life" of the various qualities of steel used in our different grades. As its action is so much like human effort, the results it would give would be of a practical and comparative character. The works of Messrs. Thos. Coleman & Sons, Limited, the patentees, is situated at Alfreton Road, Derby.

V. C. F.

Deoxidisers in Steel.—In an effort to classify the various factors which might effect the formation of porous welds, Mr. Wilmer E. Stine tested several hundred specimens of different grades of steel, using an automatic shielded carbon arc-welding machine. He found that steel which formed slag holes in the weld invariably had been aluminium-killed and contained an appreciable amount of Al_2O_3. This characteristic was checked by covering a piece of good welding steel with a thin layer of Al_2O_3 before welding it. A porous weld was the result. Excess amounts of silicon and manganese produced porous welds also, although not to the same degree as aluminium.

Progress in Blast-Furnace Practice.—A recent development in blast-furnace practice is the use of a refractory-lined blowpipe for conducting the blast into the furnace, particularly at stacks where hot-blast temperatures in the vicinity of 1,500 deg. Fah. are carried. The refractory blocks, which have a low thermal conductivity, are placed in their correct position in the mould before the blowpipe is cast. At a plant making merchant iron the use of insulated blowpipes has decreased the heat radiation about 30,000 B.T.U. per min. per blowpipe. At another stack it has been found that in event of a kick-back, the slag in the blowpipe remains molten and the blast in most cases blows it back into the tuyere zone, leaving only a thin glaze on the refractory lining. A recent test conducted on a steelworks stack using refractory-lined pipes revealed that the hot-blast temperature at the face of the tuyeres was 28 deg. higher than when unlined cast-iron blowpipes were used on the same furnace. The lining prevents warpage and cracking and affords the furnace crew a greater factor of safety.—"Steel."

The Copper Crisis.

By "Onlooker."

The copper market has latterly been as full of changes as the "movie pictures," and the situation has altered almost hour by hour in accordance with rumours, true and false, regarding the conference on curtailment in New York. The progress of the negotiations there has been faithfully recorded in the daily quotations on the Metal Exchange, for speculators have been active, and bull and bear movements became exaggerated in consequence. Supply and demand have affected the position very little, for supply is a known (and a very onerous) quantity, while demand is on a modest and hesitating scale. As usually happens when a market is awaiting developments, a nervy atmosphere has prevailed, and the swing of the pendulum has been both wide and erratic.

Up to about mid-November, sentiment, although affected by the confusing reports from New York regarding the progress of the curtailment negotiations, was, on the whole, optimistic, but on news coming through that the Belgian representatives at the copper conference had sailed for home the tone turned very bearish, and it was soon evident that the market had been reckoning rather whole-heartedly upon curtailment agreement. As a result, standard copper was very heavily sold, both on home and foreign account, and with a turnover of practically 10,000 tons a loss of £4 was seen on the week's trading, while in the States the quotation came down to 6½ cents, with offers reported at 6⅜ cents. After holding on to 7½ cents for two months, the Exporters brought their price down by ½ cent, but even so, the quotation is certainly out of line with the domestic figure, and the real level of copper was more fittingly shown by the London Metal Exchange wire-bar price at £41.

The true facts of the failure to agree upon a policy of output curtailment are difficult to ascertain, for in the absence of any official statement the blame for a breakdown is being laid upon the Americans, the Belgians and the Rhodesians in turn. Time spent in pursuit of a scapegoat is, however, merely wasted, for what is wanted, if copper is to be saved from a disaster of the first magnitude, is a scheme for reducing output and avoiding a price war, which can only end in the wholesale closing down of mines all over the world. The disorganisation which would inevitably follow such an event would persist for years, and would result in even greater confusion and loss of confidence than exists at present. A price war is now being freely discussed, and as the result of fears of such an event the selling pressure in London has been very severe, but buyers were forthcoming, and the market has been characterised by a noteworthy absence of panic.

Not unnaturally, a break-up of Copper Exporters has been very freely discussed, and although so far nothing definite is known, there are good grounds for believing that the fate of this selling organisation hangs in the balance. In its ideal of conception the copper cartel may be sound, but unfortunately events have shown that the methods employed in the translation of these ideals into practice were faulty. In two words, the policy adopted has been one of restriction rather than expansion of sales, and any success which Copper Exporters may have had with consumers here must be ascribed to the ability and energy of their agents in pushing wares hedged around by irritating restrictions. The survival of the Exporters appears to be doubtful, but unless they fling all their embargoes into the limbo of forgotten things and decide to go out of their way to encourage trade, they will be lost indeed.

The Renishaw Iron Company, Limited, Chesterfield, is making preparations for the relighting of a blast furnace at the end of the month.

A Comparative Study of Some Properties of Pig-Irons.*

By J. E. Hurst.

The view is freely held that the qualities or properties of pig-irons are not wholly defined or to be understood from the examination of their chemical composition alone. It is held that distinct differences in properties exist between various brands of pig-iron which cannot be predicted in this manner. These differences in character, quality or properties are often referred to as inherent or intrinsic properties and their existence after subsequent remelting and working in the foundry is discussed under the title of heredity in pig-irons.

These views have arisen directly from practical experiences in which differences in such properties as strength, toughness, durability and liability to chill are revealed, and which it does not appear possible to correlate with the simple chemical composition. Of these many differences in properties, it is the strength properties with which this investigation is concerned mainly. It has always appeared desirable to the author that an attempt should be made to ascertain in some quantitative manner the existence of differences in strength properties of various brands of pig-irons, as a step in elucidating the nature and origin of any of these intrinsic properties.

This study, which was commenced some time ago, largely originated from the realisation of the value of the ring test as utilised in the B.E.S.A. specifications for piston-ring materials, as a simple comparative means of evaluating the strength properties of cast iron, with particular reference to its elastic behaviour. In the ordinary commercial testing of the strength properties of cast iron, the ultimate breaking strength only is of primary importance. Beyond the determination of the total deflection experienced during the transverse loading test, no attempt is made to follow more closely the manner of breaking or to examine the other attributes of the strength properties such as stiffness, toughness or even ductility.

Methods of Testing.

The study of these various attributes of the strength properties involves the determination of the degree and character of the strain or deformation under varying conditions of stress or loading. The very small magnitude of the strain or deformation in cast-iron specimens of ordinary dimensions is one of the principal difficulties in a study of this kind. In some early experiments referred to by Anderson it was endeavoured to overcome this difficulty by subjecting extremely long bars, 10 ft. long by 1 in. sq., to tensile loading, and in this manner magnifying the extensions. Even with this type of bar, experiment records a specimen in which the total extension at a breaking load of 7.43 tons per sq. in. was of the order of $\frac{3}{16}$ in. only. It can be imagined that the practical difficulties in the production of such gigantic test-pieces of a suitable character must more than counterbalance the ability to measure more easily their deformation under loading. The use of more precise and delicate measuring instruments on specimens of normal length has been utilised in more modern investigations. These methods, of course, can only be carried out under the most careful conditions and circumstances such as exist only in a few research laboratories.

The transverse loading test commonly applied to cast iron offers a readier means of studying the deformation of cast iron under load. The deflections experienced on common sizes of transverse test-bars are of considerably more tangible magnitude. Even with these larger deflections the transverse test as ordinarily carried out requires considerable modification to make it suitable for investigating the elastic behaviour of the specimens. All the modifications required are in the direction of improving the accuracy of the test. A modified form of transverse test for the specific purpose of investigating the elastic behaviour of cast iron has been designed by Fremont. A description of this apparatus has been given in English by Ronceray.* The Fremont test is performed in exactly the same manner as the ordinary transverse test, the machine being equipped with an autographic recorder designed to produce a direct record of the change of strain, deformation or deflection with change in stress or load. In practice Fremont adopted very small specimens of 10 mm. wide by 8 mm. thick by 35 mm. in length. The object of using such small specimens was to enable samples to be taken from actual castings and from different parts of the same casting. This is a perfectly laudable object, but unfortunately the smallness of the specimens has provided cause for considerable objections to be raised. Of all the objections which have been raised to the use of such small test-specimens, that which is the most pertinent is the limit which this smallness imposes on the accuracy of the test.

A form of static transverse bending test to which the Fremont test bears some resemblance was designed by Captain Philpotts and utilised by him in his comparative study of the impact test applied to steels. The transverse method of bending was utilised also by J. T. Mackenzie in his studies of the modulus of elasticity of cast iron.

The test for piston-ring material utilised in the B.E.S.A. specifications might be regarded as a modification of the ordinary transverse test. Details of this test are embodied in full in the B.E.S.A. specification No. 5004 and 4 K 6 (Aircraft Material specification). This test utilises a gapped ring-form specimen, very similar in form to a piston ring. The specimen affords convenient facilities for the determination of the breaking strength, modulus of elasticity and the relation between the stress and deformation under continual increments of stress. Except for the fact that the specimen is curved and the cantilever ends unduly long the test is very similar in form to the ordinary transverse test. The method of utilising the ring test in this investigation is described in detail below.

Ultimate Breaking Strength.

The ultimate breaking strength is determined by pulling apart the split or gapped ring by a load applied across that diameter of the ring at right angles to the diameter passing through the gap. The breaking load obtained in this manner is expressed in the terms of the B.E.S.A. specification 5004 as tensile strength. The relationship between breaking load and tensile strength as given in the specification is as follows:—

$$S = \frac{Pd}{1{,}200\ bt^2},$$

where S = stress in tons per sq. in. (designated tensile strength),
P = load required to break the ring in lbs.,
d = external uncut diameter of ring in in.,
t = radial thickness of ring in in.,
b = breadth of ring in in.

For the sake of uniformity this method of determining and expressing stress values has been adhered to throughout this investigation. Actually, the above relationship embodies an empirical constant derived by comparing the results obtained from rings with direct tensile tests on the same material. It would be better probably to express the results directly as moduli of rupture, particularly as the results expressed in this form are more commonly understood. Using the same notation the relationship would be:—

$$S = \frac{Pd}{748\ bt^2},$$

where S = modulus of rupture.

For comparison purposes the tensile strengths recorded in this investigation can be converted into rupture moduli by multiplying by the factor 1.60.

Stress/Deflection Curves.

During the determination of the ultimate strength in the manner indicated above, the study of the deflection in relation to the increment of loading has been carried out. The value of the deflection or deformation can be obtained either by measuring the change in diameter across which the load is applied or the change in gap opening. In this investigation the change in gap opening has been adopted. In the actual test the increments in gap opening for various increments in loading up to breaking have been recorded. In plotting the results the loads have been converted to stress values utilising the B.E.S.A. relationship as given above. The curves obtained are similar in form to stress/strain curves. It is necessary to point out that the author is fully aware that these diagrams cannot be regarded as true stress/strain diagrams by reason of the method of obtaining the stress values and the utilisation of the gap opening as a measure of the strain. The justification for their use in commercial testing lies in the fact that the specimens can be prepared and the measurements made with considerable accuracy. Interpreted in a comparative manner these stress/deflection diagrams provide most of the information that could be obtained from the true stress/strain diagrams, the preparation of which, to equivalent accuracy for a material like cast iron, would require almost impossibly elaborate precautions.

One of the most important indications of these stress/deflection diagrams is derived from the included area. The value of the included area of these curves is proportional to the energy required or the work done in breaking the specimens. For the same reasons as above this value is expressed as a mere number representing the area in square inches at the original scale of plotting. This number is proportional to the energy units absorbed in breaking the specimens and is referred to as the *resilience* value. In adopting this nomenclature the author is following the Continental practice which defines resilience as the energy absorbed in breaking material. In this country resilience is more strictly defined as the energy stored up in raising material to its elastic limit.

From experience it has been found that on subjecting cast-iron specimens to loading they take on permanent set. The amount taken on in the initial loading is quite appreciable. With the centrifugally-cast material, in most cases the amount of permanent set is considerably diminished on second loading. For the sake of uniformity a somewhat arbitrary procedure has been adopted. All the specimens have been subjected to an initial loading to a stress value corresponding to 14 tons per sq. in., prior to the second loading for the determination of the stress deflection diagram. The *Initial Permanent Set* value has been recorded by measuring the permanent change in gap after the initial load of 14 tons per sq. in. has been removed. This value expressed as a percentage of the total change in gap at the stress value of 14 tons per sq. in. has been recorded as the *Initial Permanent Set*.

In all cases the stress/deflection results when plotted have yielded smooth curves. A number

* Paper read before the Manchester Association of Engineers on November 13.

* "Proceedings," Institute of British Foundrymen, Vol. xv, p. 26 *et seq.*

of these show traces of a marked limit of proportionality. This has been recorded at the corresponding stress value at which it occurs. It is necessary to point out that this stress value is calculated from the B.E.S.A. relationship and the use of the phrase "limit of proportionality" is purely confined to the indications of this test.

Modulus of Elasticity or En. Value.

The method of determining the modulus of elasticity or En. value utilises the same form of test specimen. The B.E.S.A. specification carefully defines the conditions under which this value is to be determined and this procedure has been adhered to in this investigation.

Experimental Work.

The above properties, together with the Brinell hardness values and the chemical compositions, have been determined on a variety of samples of pig-irons after remelting under controlled and uniform conditions. The Brinell hardness determinations have been made with a Firth hardometer, utilising the diamond indenter.

Preparation of Test-Samples.

The samples of the respective pig-irons to be tested were remelted and cast into the form of a standard piston-ring drum by the centrifugal process. The remelting was carried out in plumbago crucibles by coke firing, and the test castings produced were of standard and uniform dimensions within the commercial limits adopted in the production of centrifugal castings (viz., a tolerance of −1 mm. to +1.5 mm. on radial thickness). Since the test castings were produced during the course of the continuous operation of the centrifugal-casting plant, the conditions of mould temperature and the system of cooling the castings were uniform within the limits which are the subject of careful control during the daily production of such castings by this process.

Rings for the purposes of the tests were machined from the test castings; the position in the casting, the dimensions and finish of the rings conformed to the standard practice adopted in the daily routine testing of piston-ring material. This procedure has been standardised carefully to ensure the maximum possible degree of uniformity. Chemical analyses were carried out on the complete turnings taken across the radial section of the test castings during the parting off of the test-rings.

Test Results.

The complete test results are tabulated in Tables I to IV. The results have been assembled under the classifications:—(1) Hematite; (2) medium phosphorus; (3) phosphoric, and (4) mottled and white irons. For obvious reasons brand identities have been omitted. With the exception of the medium phosphorus series the results have been tabulated in the order of descending silicon contents. The medium phosphorus results have been tabulated in the order of descending phosphorus contents, although with one or two exceptions, it happens these are very nearly in the order of descending silicon contents. Selected examples of the stress/deflection curves are given in Figs. 1 to 3.

In making a general survey of these results as tabulated, there are quite a number of individual points of great interest, but there appears to be no really clear relation between the various items of the strength properties.

It appears possible to draw a broad conclusion that the amount of phosphorus present tends towards high resilience values (total area of stress/strain curve), also that high-silicon and mottled and white irons have high En. values and also high ultimate-strength values. The high-phosphorus irons have lower strength and resilience values, the En. value not being greatly affected. The limits of proportionality, permanent set and Brinell hardness values vary irregularly in all cases. Each of these broad conclusions is subject to outstanding exceptions, and possibly the existence of these is of greater interest than any general conclusions.

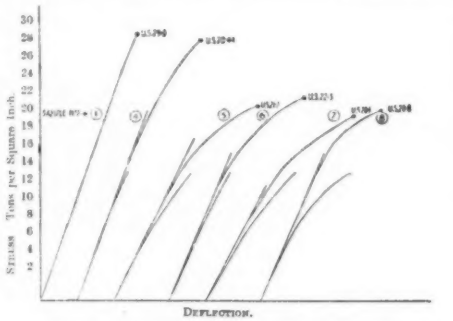


Fig. 1.—Stress/Deflection Curves, Hematite Iron Series.

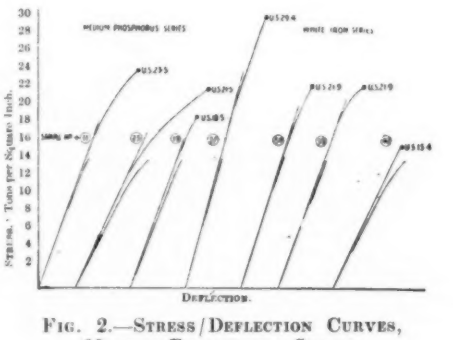


Fig. 2.—Stress/Deflection Curves, Medium Phosphorus Series.

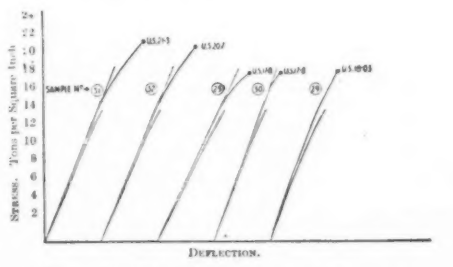


Fig. 3.—Stress/Deflection Curves, Foundry Iron Series.

Table I.—*Hematite Irons.*

Sample No.	Chemical Analysis. T.C. Per cent.	C.C. Per cent.	Gr. Per cent.	Si. Per cent.	Mn. Per cent.	S. Per cent.	P. Per cent.	Mechanical Properties. U.S. Tons per sq. in.	En value, lb. per sq. in. × 10^6	Total area stress/deflection curve.	Limit of proportion'ly. Tons per sq. in.	Permanent set. Per cent.	Brinell hardness.
1	3.43	0.03	3.40	6.53	1.27	0.024	0.076	29.0	18.6	38.4	15.0	1.94	320
2	3.46	0.26	3.20	3.76	1.10	0.021	0.060	28.8	18.5	70.2	15.0	7.7	226
3	3.49	0.13	3.36	2.86	1.28	0.047	0.060	20.1	16.7	33.0	9.0	12.1	209
4	4.42	0.52	3.90	2.65	1.26	0.022	0.036	28.4	18.6	56.0	15.0	7.15	255
5	4.31	0.67	3.64	2.35	1.04	0.032	0.046	21.2	15.5	55.4	10.0	16.3	217
6	4.31	0.68	3.63	2.23	1.32	0.029	0.049	22.3	16.8	57.5	12.0	11.75	228
7	3.89	0.26	3.63	2.14	0.80	0.053	0.048	20.1	15.0	51.0	10.0	20.0	207
8	4.32	0.27	4.05	1.95	0.59	0.028	0.071	20.8	16.2	43.4	11.0	25.0	207
9	3.49	0.27	3.22	1.74	0.40	0.130	0.090	21.8	19.3	38.5	11.0	18.6	226

Table II.—*Medium-Phosphorus Irons.*

10	3.87	0.13	3.74	3.06	1.18	0.012	0.86	20.04	17.1	22.4	14.0	5.25	201
11	3.98	0.46	3.52	2.28	0.76	0.041	0.76	23.5	17.9	46.6	15–16	5.6	209
12	3.98	0.42	3.56	2.54	0.92	0.020	0.72	17.9	17.7	25.2	—	9.75	228
13	2.97	0.11	2.86	2.94	1.04	0.074	0.70	16.45	17.9	15.75	—	8.6	269
14	3.32	0.08	3.24	2.25	0.98	0.073	0.66	17.3	19.4	17.71	15·0	9.10	269
15	3.66	0.26	3.40	2.19	1.15	0.053	0.61	20.6	17.5	27.17	17.5	10.3	266
16	3.98	0.18	3.80	1.64	0.55	0.079	0.55	20.1	16.5	39.5	10·0	14.5	235
17	3.37	0.67	2.70	1.91	1.04	0.054	0.49	20.8	17.2	38.36	10·0	7.2	269
18	3.27	0.67	2.60	1.41	0.45	0.190	0.48	21.0	19.5	32.37	13·0	10.7	245
19	3.28	0.51	2.77	1.92	0.80	—	0.44	18.5	19.2	17.47	—	8.35	248
20	4.07	—	—	1.18	0.50	0.042	0.30	18.06	16.9	23.22	12·0	12.3	269
21	3.77	0.27	3.50	1.86	0.88	0.079	0.32	18.9	16.2	26.39	—	20.2	209
22	4.04	0.02	4.02	1.53	1.01	0.034	0.22	22.6	17.0	50.25	14.0	12.5	235
23	3.41	0.11	3.30	1.95	0.87	0.028	0.17	21.2	16.8	47.46	10.0	16.0	241

Table III.—*Phosphoric Irons.*

24	3.20	0.15	3.05	4.16	0.35	0.044	1.63	23.24	18.1	30.76	—	7.6	302
25	3.60	0.26	3.34	3.90	0.33	0.026	1.92	17.8	16.9	25.85	12.0	9.45	255
26	3.32	0.02	3.30	3.85	1.00	0.048	1.27	17.6	16.9	16.59	14.0	6.6	266
27	3.43	0.13	3.30	3.64	1.42	0.013	1.57	16.2	18.3	13.75	—	3.12	286
28	3.32	0.02	3.30	3.38	1.29	0.022	1.38	16.2	17.6	13.6	—	8.11	205
29	2.89	0.09	2.80	3.34	0.35	0.022	1.73	18.2	18.5	18.53	—	10.15	209
30	3.71	0.52	3.19	2.70	0.96	0.022	1.65	17.8	18.0	18.03	14.0	7.6	205
31	3.55	0.95	2.60	2.47	0.42	0.032	1.32	21.28	16.9	33.15	—	11.15	269
32	3.93	0.39	3.54	2.25	0.44	0.083	1.56	20.7	17.5	30.97	13.0	9.25	286
33	3.37	0.27	3.10	1.79	0.32	0.036	1.65	17.7	17.0	20.48	12.0	14.5	228

Table IV.—*Mottled and White Irons.*

34*	2.48	1.18	1.30	2.28	0.93	0.034	0.62	21.9	22.3	22.9	16–17	2.31	418
35†	3.55	3.04	0.51	1.88	0.68	0.090	0.24	28.8	23.2	28.8	Nil	3.9	390
36†	3.85	2.32	1.53	1.58	0.54	0.082	0.29	20.9	19.9	21.86	18.0	4.87	412
37†	3.43	2.77	0.66	1.33	0.52	0.072	0.23	29.4	24.4	34.38	18–20	1.67	412
38†	3.98	2.55	1.43	1.01	0.58	0.089	0.41	22.9	22.2	24.73	12.0	2.74	390
39*	4.25	1.50	2.75	0.96	0.68	0.072	0.52	21.9	18.4	28.0	16–17	4.75	278
40*	3.87	1.17	2.70	0.87	0.54	0.060	0.58	15.4	16.3	14.3	Nil	2.5	302

* Mottled irons. † White irons.

Ultimate-Strength Values.

Broadly the hematite, medium-phosphorus and white-iron groups are higher in ultimate-strength value than the phosphoric irons. There are exceptions in which the phosphoric irons show ultimate strengths equivalent to the higher results in other groups. Also the medium-phosphorus and white-iron groups contain examples where the ultimate strength is as low as the phosphoric-iron group.

Modulus of Elasticity. En. Value.

The consistently higher values of this property in the white iron is in accordance with experi-

ence. The variation in En. value in the remainder of the samples is irregular. It apparently bears no relation to the ultimate strength value or to the other properties.

Total Area of Stress/Strain Curves.

The two most important observations in regard to this property are that it apparently bears no relation to the ultimate-strength value and the consistently high values of the hematite series. This latter reflects the common experience of the difficulty of breaking hematite pig-iron. Even with this property there are variations. Several of the medium phosphorus irons (serial Nos. 11, 16, 17, 22 and 23) give values almost equal to the high hematite values and the sample of hematite (serial No. 3) shows a much lower value of this property than the others (with the exception of the siliceous hematite) in spite of its high ultimate-strength values.

This property should be considered in conjunction with the stress/deflection curves. The difference in character of the curve for the siliceous hematite (serial No. 1) is most noticeable. This type of curve is broadly characteristic of siliceous irons. With this exception, the pronounced character of the limit of proportionality and the magnitude of the plastic deformation portion of the curves is characteristic of the hematite series. These characteristics are almost equalled in the above-mentioned samples of medium phosphorus (11 and 23, Fig. 2). The difference in these characteristics in the remainder of the curves will be noticed also. These differences are partially reflected in the values which have been assigned to the limit of proportionality.

Permanent-Set Value.

The differences in this value are most irregular. The white irons and the siliceous hematite show remarkably low values, whilst the remainder of the hematite series show the maximum values although they are markedly different in individual samples.

Brinell Hardness (Diamond Hardness Numeral).

The whole of these values are consistently high, due, of course, to the centrifugal method of casting (with the exception of the white irons). The irregularities in the values appear to bear no relation to the other properties. The high values for the siliceous foundry and hematite irons (serial Nos. 1 and 24) will be noticed, as will also the remarkably low values for the mottled irons (serial Nos. 39 and 40). These two latter samples were machined with ease. The difficulty in relating the hardness values to the chemical composition is exemplified particularly by the samples (serial Nos. 27, 31 and 32).

Consideration of Stress/Deflection Curves.

The various complete curves obtained after second loading differ in length or height, degree and character of curvature. The height of the curves represents the ultimate breaking strength and the variations reflect the variations in ultimate breaking-strength values recorded in the tables. When the curves are examined for degree and character of curvature they can be divided essentially into three classes as follow:—(1) Those which closely approximate to straight lines from the origin to the ultimate breaking point; (2) those which closely approximate to straight lines up to a stress value below the breaking point, beyond which they show distinct curvature towards increased deflection; and (3) those which show distinct curvature from the origin to the breaking point. As examples of Group 1, the curves for samples Nos. 1, 27 and 28 are the only ones which occur in this series of results. In many of these cases which fall in Group 2 the degree of curvature is very small, but the majority of the results fall within this category. Most of these examples, where no limit of proportionality is recorded, fall within category No. 3.

The difference in both the stress value at which the curvature commences and the degree of curvature in those examples which fall within Group 2 is very marked, and is clearly illustrated both in Table I and the illustrations. The stress value at which the curvature commences has been called the limit of proportionality.

It will be clearly recognised that these differences in character of the curves have a large influence on the value of the included area of the curves. The included area of the curves is further influenced by the angle of slope, which is also seen to vary amongst the samples tested. The slope of the curves indicating as it does the rate of deflection with increasing stress is proportional to the modulus of elasticity or En. value. The straight-line relationship which exists between these two values over a given stress range is a property of importance in the application of cast iron to the manufacture of piston rings.

These characteristics of the stress/deflection curves indicate certain important differences in the strength properties of these test-samples and are summarised as follow:—

(1) The differences in vertical height of the final point on the curves indicate the differences in ultimate breaking strength.

(2) The differences in horizontal length of the final point on the curves indicate the differences in the ultimate deflection of the breaking point.

(3) The differences in slope of the curves at a given point indicate the differences in modulus of elasticity, or stiffness, or the magnitude of stress required to produce a given deflection. The steeper the slope to the vertical the greater the modulus of elasticity or stiffness.

(4) The straightness of the curves indicates the nearness of approach to conditions of true elasticity where the magnitude of the strain is in simple proportion to the stress. Possibly it is also an indication of the nearness of approach to conditions of true elastic recovery after strain within the limit of proportionality.

(5) The differences in curvature indicate the differences in degree of plastic deformation undergone by the specimens in breaking.

(6) The differences in included area of the curves indicate the differences in the energy absorbed in finally breaking the specimens. The indications of (5) and (6) combined may be taken possibly as indications of the comparative brittleness of the specimens. The greater the included area and the greater the amount of curvature (or plastic deformation), the less brittle the specimens. If the foundrymen's conception of toughness is regarded as the reciprocal of brittleness then (5) and (6) may be utilised in comparing the relative toughness of the specimens.

The first two of these indications are identical in character with those of the transverse test for cast iron as ordinarily carried out, *i.e.*, the measurement of breaking strength and deflection. The others are additional and give further information regarding the comparative strength properties and the differences in behaviour of cast iron during breaking.

It is necessary to refer to the indications of the permanent-set value. This value as determined is represented on the curves by the horizontal difference in position between points of the same stress value on the curves for the first and second loading respectively. The value is expressed in the Table, the numeral being obtained in the manner previously described. That cast iron takes up permanent set on repeated loading has been known for a long time (see Anderson or Morley on "Strength of Materials"). Due recognition has been given to this in the recommended methods of carrying out the determinations for modulus of elasticity (En. value) in the B.E.S.A. specifications. It is considered that this permanent set may be due in part to the overcoming of initial stress in the metal since it cooled from the liquid state. The behaviour of cast iron from this point of view is, however, a matter which is being studied separately and it is sufficient for the purposes of this Paper to note the variations in this value obtained on the different samples under uniform conditions of testing.

General Considerations.

The ultimate strength is the property most commonly used by foundrymen in evaluating irons. By rearranging the results set out in the Tables in the order of descending ultimate strengths (omitting the white irons) and dividing them into groups of approximately the same ultimate strengths, each group will show that such properties as modulus of elasticity, area of stress/deflection curve; character of stress/deflection curve; permanent set value; limit of proportionality and Brinell hardness vary within wide limits. In other words, for the same ultimate-strength value the properties of stiffness, toughness and hardness of the various samples of pig-irons remelted and cast under as nearly as possible identical conditions, differ considerably. The variations in chemical composition of the samples make it impossible to produce clear direct evidence as to whether or not these variations are in any way related to the chemical composition. On the other hand, it would appear to be possible to produce indirect evidence from these results that some factor other than the chemical composition exerts an influence on the properties.

For example, if one extracts Nos. 17, 19, 11, 12, 2 and 3, one includes two sets of two samples of approximately the same chemical composition showing substantial variations in the complete strength properties. The final pair of these results are also of importance in that it is clear that the large difference in resilience value cannot be accounted for solely by the difference in silicon content.

Concluding Remarks.

The main object in publishing these results is to demonstrate certain aspects of the strength properties of cast iron which are not revealed by the tensile and transverse tests as ordinarily carried out. These aspects of the strength properties can be evaluated in various ways, and the method used here is based simply on the form of test adopted in B.E.S.A. specifications 5004 and 4K6. It is possible that these aspects of the strength properties are closely related to the foundryman's concept of toughness and his practical experiences in the difficulty of breaking iron. Probably they are also amongst those properties which are referred to frequently as immeasurable and described as inherent or intrinsic properties. Ultimate breaking strength alone is insufficient as a measure of the properties of toughness. The area included by the stress/strain curve is a close measure. Even this is not sufficient, and the character of the deformation sustained during loading or the shape of the curve must also be taken into consideration. Whilst the transverse test as ordinarily carried out, including the measurement of total deflection, is a partial guide to the toughness, it is clearly insufficient, as it gives no record of the character of the deformation sustained during loading or the energy absorbed during breaking.

The results of these tests applied to a series of pig-irons remelted in crucibles and cast by the centrifugal process under identical conditions are given in the Paper. Substantial variations in the properties are revealed, the nature and causes for which require further study.

The majority of the tests recorded have been made in the research laboratories of Messrs. Sheepbridge Stokes Centrifugal Castings Company, Limited. The samples of pig-iron and the analyses of the test-samples have been supplied by Messrs. Bradley & Foster, Limited, Darlaston. The author's thanks are due to the directors of both these companies for the permission to publish these results.

Uneven Oil-Stones can be resurfaced by rubbing them on a flat stone surface, using wet builders' sand as an abrasive.

XUM

This Week's News in Brief.

Trade Talk.

Damage estimated at £1,500 was caused by fire last week at the works of George Kent, Limited, Luton.

Messrs. Elton, Levy & Company, Limited, London, have purchased the airship R.100 for breaking up.

The Darlington Rolling Mills Company, Limited, has completed the erection of a second 12-in. mill.

Participating in the trend of improved business, Albion Motors, Limited, Glasgow, have within the past week booked orders for over 100 more vehicles of various types.

Messrs. Henry Pooley & Son, Limited, ironfounders and weighing-machine manufacturers, are closing down their works at Kidsgrove and concentrating operations at their Birmingham works.

The secretary of the Newmains and District Miners' Welfare Society has been notified by Mr. W. H. Telfer, managing director of the Coltness Iron Company, Limited, that the directors of the company have decided to present a bandstand for the new recreation ground in Newmains.

It is reported in German papers that, on account of the inconvenience to customers and high management costs due to over-centralisation, the United Steelworks in Germany are contemplating a division of the control at Düsseldorf into several sub-divisions at different towns in the Rheinish-Westphalian district.

An extension to the research laboratories of the English Steel Corporation, Limited, at Vickers Works, Sheffield, was opened last week by Sir Joseph Thomson, Master of Trinity College, Cambridge. There were present a number of Government Department representatives, and representatives from steelworks in many parts of the country.

An arrangement has been entered into between G.W.B. Electric Furnaces, Limited (Gibbons Bros., Limited, and Wild-Barfield Electric Furnaces, Limited), and Demag-Elektrostahl G.m.b.H., Düsseldorf, whereby G.W.B. Electric Furnaces, Limited, will have the sole selling rights for Demag electric aluminium melting furnaces in the British Isles. These furnaces are at present made up to a capacity of about 2 tons and an input of 500 kilowatts.

The Millom & Askam Hematite Iron Company, Limited, has issued a circular to the shareholders, which states that the company has acquired the control of the North Lonsdale Iron & Steel Company, Limited, Ulverston. The exchange has been effected on a basis of giving for one-sixth of the North Lonsdale shares an equal number of 7 per cent. cumulative and participating preference shares in the Millom Company, and for the remaining five-sixths of North Lonsdale ordinary shares in the proportion of three Millom shares for four North Lonsdale shares. The North Lonsdale Company has a controlling interest in the Whitehaven Hematite Iron & Steel Company, Limited.

Messrs. Henry Simon, Limited, Cheadle Heath, Stockport, have taken over the business which has been carried on for many years by Turbine Gears, Limited, Hyde. In future, the manufacture of double helical and other gears will be undertaken at Messrs. Simon's works at Cheadle Heath. In order to retain the individuality, a new company has been formed, and the trading activities of the gearing section will be carried on as Turbine Gears, Limited (subsidiary of Henry Simon (Engineering Works), Limited). All communications should be addressed to Cheadle Heath, Stockport. The technical and designing staffs of Turbine Gears, Limited, have been retained, and special gear-cutting machinery from the Hyde works has been transferred to Cheadle Heath, where Messrs. Henry Simon, Limited, already have up-to-date plant upon which the greater part of the gears for their standard products is produced. The extended plant is now capable of dealing with gearing up to the largest requirements for all general purposes.

Natural Oil-Stones can be lubricated with neatsfoot oil, and artificial oil-stones with a mixture of two parts of machine oil and one part of paraffin oil.

Obituary.

Mr. W. S. Skelton, a director of Messrs. C. T. Skelton & Company, Limited, Sheffield, died on November 12, aged 73.

Sir Hallewell Rogers, deputy-chairman of the Birmingham Small Arms Company, Limited, and a director of other companies, died in Birmingham recently. He was 67 years of age.

We sincerely regret to announce the death of Mr. Leon Thomas, a Past-President of the French Foundrymen's Technical Association. Mr. Thomas was a consulting engineer, previously having been foundry manager to Citroen, one of the largest automobile foundries in Europe.

The death occurred suddenly on November 17, at Cove, of Ex-Bailie John King, formerly chairman of Messrs. David King & Sons, Limited, Keppoch Iron Works, Glasgow. Mr. King was 79 years of age, and was well known in the foundry trade of Britain. Born in Glasgow, and educated at St. George's School and Anderson's College,

The Late Ex-Bailie John King.

Glasgow, he attained prominence as an ironfounder. He took a leading part in the formation of the National Light Castings Association, and became its chairman—a position he held until last year, when the Association was reorganised and became the British Ironfounders' Association. Mr. King also played an important part in the establishment of the Scottish Branch of the Institute of British Foundrymen, and was elected its first President. In 1916 he was appointed by the President of the Board of Trade as a member of the Departmental Committee to consider the position of the iron and steel trades after the war. He was also a British delegate to the Inter-Allied Commercial Conference held in America in 1919. Mr. King devoted much time to public work, and was a member of the Town Council of Glasgow for about 15 years, and was appointed senior magistrate in 1902.

Mr. J. J. Burton, for many years a prominent figure in the Tees-side iron and steel industry, died on Saturday, November 14, at his home in Nunthorpe, aged 83. Born near Huby, Easingwold, Mr. Burton, as a young man, entered the service of Messrs. Swan, Coates & Company (afterwards the Cargo Fleet Iron Company, Limited) as an accountant. He afterwards became secretary and director of this firm, with which he remained for 41 years. The war provided Mr. Burton with ample scope for his energies, and during the early period he was one of four appointed by the Admiralty to license the export of pig-iron from this country. On the establishment of the Ministry of Munitions he became a member of a small committee appointed as a North-East Coast Pig-iron Control Committee. A little later during the war he was appointed chairman of the Cleveland Potash Committee, the Limestone and Ironstone Control Committee, and the North-East Coast Imported Ore Control Committee. He was also the North-East Coast representative on the Central Ore Control Committee, sitting in London. In 1917, when the Government appointed a Central Advisory Committee for the iron and steel industry to deal with labour questions in anticipation of demobilisation of the forces, Mr. Burton was appointed chairman, and he was also a member of the Resettlement Committee under the presidency of the Minister of Labour. He was a Vice-President of the National Federation of Iron and Steel Manufacturers and a member of the Executive Council of the National Confederation of Employers' Organisations. His mining knowledge was utilised when the Government appointed him a continuous member of the Ministry of Mines Advisory Committee under the Metalliferous Mines Act, and for some years he had been its chairman. For services in this capacity he was awarded the O.B.E. in 1929. He first became President of the Cleveland Ironmasters' Association in 1907, and again from 1917 to 1919. He was also a Vice-President of the Cleveland Mineowners' Association. Mr. Burton had taken a prominent part in local government affairs. After serving on the Stokesley Rural District Council for 19 years he retired three years ago. Out of a period of 21 years on the Board of the Stokesley Guardians he was chairman for 11 years, retiring from the chair with the passing of the Guardians in April, 1930.

Personal.

Mr. William Drysdale, rolling-mill foreman at Dalzell Steelworks, Motherwell, who had a record of 49 years' service with Colvilles, Limited, has been the recipient of a presentation on the occasion of his retirement.

Mr. A. G. MacFarlane, director of William Beardmore & Company, Limited, was entertained to dinner in Glasgow by Mr. H. A. Reincke, chairman of the company, to mark his 25 years' association with the company. Mr. MacFarlane has occupied many positions of responsibility during his association with the firm, and has been a director for the last few years.

Sir Thomas Putnam has resigned from the board of the English Steel Corporation, Limited. Mr. D. M. Anderson, Mr. Leslie Hood, Mr. Alexander Williamson and Mr. A. B. Winder have resigned from the board of Darlington Forge, Limited, and Colonel D. S. Branson, of Messrs. Branson & Son, solicitors, of Sheffield, has been appointed a director as the representative of the English Steel Corporation, Limited.

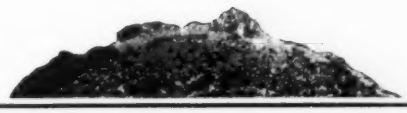
H.M. the King of Italy has awarded to Ing. Comm. C. Vanzetti, C.B.E., the high decoration of "Cavaliere al Meriot del Lavoro" (Chevalier au Merite du Travail). Comm. Vanzetti was chairman of the Executive Committee of the recent International Foundry Congress held in Italy, and the success of this Congress was largely due to his inspiration and to the large amount of work which he did in connection with it. He is Past-President of the International Committee of Foundry Technical Associations, a member of the Institute of British Foundrymen and honorary correspondent member of the Institute for Italy. His many friends in this country will unite in congratulating him upon this acknowledgment of his great services to the foundry industry.

New Companies.

Processed Light Alloys, Limited, 123, Abbey House, Victoria Street, London, S.W.—Capital £100 in 1s. shares.

J. Glover & Sons, Limited, Oldbury Works, Groton Road, Earlsfield.—Capital £5,000. Ironfounders and mechanical engineers.

Defects in Metal Patterns.—A reader inquires if there is any filling on the market, which can be applied with a brush, for treating blemishes on cast-iron pattern plates, which will give a smooth surface and withstand a certain amount of heat.



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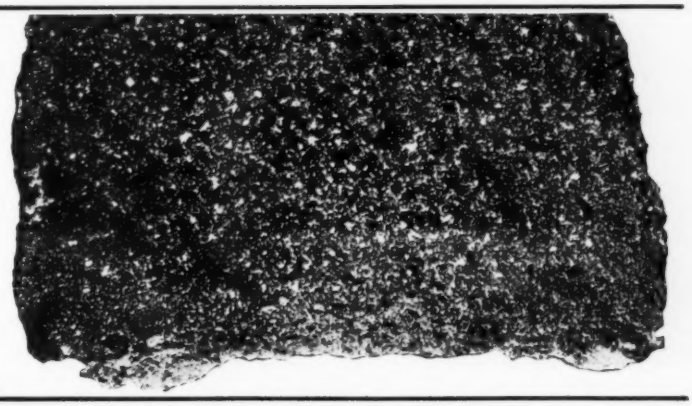

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Raw Material Markets.

The pig-iron markets have quietened down somewhat, most consumers having already covered their requirements to the end of the year. It is pleasing to note, however, that good deliveries against current contracts are being taken, particularly by the light-castings foundries. The heavy engineering side shows little improvement. It is reported that two more furnaces are to be restarted on the East Coast, in order to replenish depleted stocks.

Pig-Iron.

MIDDLESBROUGH.—The outlook of this market seems for the moment quite promising. Although only small supplementary parcels are being bought, owing to the fact that consumers of pig-iron appear to have covered most of their requirements up to the end of the year, deliveries under contract are on a heavier scale, and commitments can only be met by steady withdrawals from stock. The export market is maintained, and there are now numerous inquiries circulating for 1932. Producers, however, are displaying some caution about accepting orders far ahead. The fixed prices are unchanged, as follow:—No. 1 Cleveland foundry iron, 61s. per ton; No. 3 Cleveland G.M.B., 58s. 6d.; No. 4 foundry, 57s. 6d.; No. 4 forge, 57s. per ton.

A further improvement is reported in the demand for hematite, and, although an increase in output is not yet justified, the heavy stocks which had accumulated are being sent away from the furnaces at an encouraging rate, and, unless there is a totally unexpected decline in business, the restarting of additional plant may be expected. Inquiries are numerous, and some big contracts are understood to be under process of negotiation. East Coast hematite is also making progress—slow, it is true—in foreign markets, and the net result is that the value of hematite tends to appreciate. East Coast mixed numbers are generally quoted at 65s., but 6d. to 1s. per ton more has, in fact, been paid.

LANCASHIRE.—The market maintains its recent improvement, but there seems little possibility for the moment of any further expansion in the demand. Consumers in the light-castings trade continue to take heavy deliveries against current contracts. For delivery in the Manchester price zone, Staffordshire, Derbyshire and North-East Coast brands of No. 3 iron are quoted at 67s. per ton, with Northamptonshire foundry iron at 65s. 6d., Derbyshire forge at 62s., Scottish No. 3 at 86s. 6d. to 87s. and West Coast hematite iron at about 81s. per ton.

MIDLANDS.—The best feature of the pig-iron market in this district is the improved consumption of foundry iron, for which an increasing demand is being made. The heavy engineering section, however, is still under a cloud. For delivery to Birmingham and Black Country stations, producers continue to quote 62s. 6d. for Northants No. 3 and 66s. for Derbyshire, North Staffordshire and Lincolnshire No. 3.

SCOTLAND.—There has been some slackening of business, due to the recent spate of forward buying, but it is reported that the producers may shortly put two additional furnaces, one on foundry iron and one on hematite, into blast in order to replenish their stocks. Scottish No. 3 foundry iron remains at 69s. 6d. f.o.t. furnaces, and Cleveland No. 3 continues at 61s. 6d. at Grangemouth.

Coke.

On the North-East Coast, good Durham furnace coke is on offer at 17s. per ton, delivered, up to the end of the year, but 6d. more is asked for contracts into 1932. In the Sheffield area, prices of Yorkshire furnace and foundry cokes are stronger, and rather higher rates are now asked.

Steel.

There are still few signs of improvement in the finished-steel trade. The small requirements of the shipbuilding and constructional engineering industries result in a scarcity of orders for the mills rolling sections, plates and joists. Small steel bars have a little better demand, and a rather bigger proportion of the orders is going to the home works than formerly. The sheet trade appears to have fallen away once more. Black sheets are quiet and the trade in galvanised sheets is disappointing. The semi-products market is steady. Export business is still hampered by exchange conditions and the possibility of import duties, and business, where it has been carried through, is for prompt account. There is a steady flow of orders for British semis, although no substantial tonnages are involved in the individual transactions. The prices quoted by the home works remain firm.

Scrap.

The tone of the iron and steel scrap market in the Cleveland area is much improved, and, although the response to the appreciation in the value of raw materials has been less marked in this district than elsewhere, prices have been definitely advancing. Merchants make 42s. 6d. per ton delivered works their minimum figure for heavy steel scrap, while up to 45s. is quoted outside the immediate area. Machinery cast iron is now at 47s. 6d. In the Midlands there has been a good demand for practically all qualities of scrap. Heavy steel scrap is quoted at 35s. to 37s. 6d. per ton delivered, while light cast iron is still at 40s. Prices in South Wales are too low to encourage suppliers to sell large quantities for forward delivery, and a moderate amount of business is being done at current prices. Heavy steel scrap in furnace sizes is at 46s. to 47s. 6d. and good cast-iron machinery scrap in cupola sizes is quoted at 52s. 6d. The Scottish market is firm, with a gradual improvement.

Metals.

Copper.—The failure of the New York copper conference has had a very disturbing effect upon the market. Partly owing to the rush of indiscriminate selling by outside concerns, the price has fallen considerably, and it is reported from America that quotations are being made as low as 6.375 cents. With the market so demoralised, buyers are naturally standing off, in the hope of a further fall. The future seems very uncertain.

Closing quotations:—

Cash.—Thursday, £33 3s. 9d. to £33 5s.; Friday, £33 15s. to £33 17s. 6d.; Monday, £33 16s. 3d. to £33 17s. 6d.; Tuesday, £33 12s. 6d. to £33 15s.; Wednesday, £33 15s. to £33 16s. 3d.

Three Months.—Thursday, £33 16s. 3d. to £33 17s. 6d.; Friday, £34 5s. to £34 7s. 6d.; Monday, £34 6s. 3d. to £34 7s. 6d.; Tuesday, £34 2s. 6d. to £34 5s.; Wednesday, £34 6s. 3d. to £34 7s. 6d.

Tin.—The rise in price can be partly attributed to the announcement of a further restriction of production. The tinplate market in this country is only steady, but the future is more promising. The demand for tin on the Continent remains very poor.

Official closing prices:—

Cash.—Thursday, £131 2s. 6d. to £131 5s.; Friday, £133 5s. to £133 7s. 6d.; Monday, £135 15s. to £135 17s. 6d.; Tuesday, £135 15s. to £135 17s. 6d.; Wednesday, £137 2s. 6d. to £137 5s.

Three Months. — Thursday, £133 5s. to £133 7s. 6d.; Friday, £135 7s. 6d. to £135 10s.; Monday, £138 to £138 5s.; Tuesday, £138 5s. to £138 7s. 6d.; Wednesday, £139 12s. 6d. to £139 15s.

Spelter.—The market remains steady, in view of the limited production and the slightly improved demand on the Continent. Conditions are such that any increase in consumption here would speedily react on the price.

Daily fluctuations:—

Ordinary. — Thursday, £13 15s.; Friday, £13 17s. 6d.; Monday, £14 3s. 9d.; Tuesday, £14 2s. 6d.; Wednesday, £14.

Lead.—Business is quiet in view of the recent buying, and prices are steady. Stocks are not so unwieldy as they have been, and current supplies are well controlled by the leading interests.

The week's prices have been:—

Soft Foreign (Prompt).—Thursday, £14 8s. 9d.; Friday, £14 11s. 3d.; Monday, £14 18s. 9d.; Tuesday, £14 18s. 9d.; Wednesday, £14 15s.

Contracts Open.

Alderton, Glos, November 30.—Providing and laying 3,000 yds. of 3-in. cast-iron water mains, for the Winchcomb Rural District Council. Mr. L. W. Barnard, Promenade, Cheltenham. (Fee £1 1s., returnable.)

Belfast, December 4.—Iron and steel stores, for the Belfast City and District Water Commissioners. Mr. W. I. Quinn, secretary, Water Office, Belfast.

Cootehill, Ireland, December 7.—Supply and erection of centrifugal pumps and electric motors, for the Urban District Council. Mr. P. A. McCarthy, 26, Lower Leeson Street, Dublin. (Fee 10s. and a deposit of £2, returnable.)

Derby, December 8.—Five centrifugal pumps and electric motors, with fittings, for the Corporation. Messrs. J. Mansergh & Sons, 5, Victoria Street, Westminster, London, S.W.1. (Fee £5, returnable.)

High Wycombe, November 30.—8,200 yds. of 6-in. and 2,517 yds. of 4-in. steel pipe, coated and double wrapped, etc., for the Chepping Wycombe Town Council. Mr. S. Young, water engineer, 71, Easton Street, High Wycombe. (Fee £2, returnable.)

Malpas, Cheshire, November 30.—Supplying and laying about 510 yds. of 3-in. cast-iron water main, etc., for the Rural District Council. Mr. A. G. Eccleston, 40, Dodington, Whitchurch, Salop. (Fee £1 1s., returnable.)

Westbourne, Hants, December 3.—About 6,000 yds. of cast-iron pipes, 4 in. to 9 in. dia., for the Westbourne Rural District Council. Mr. W. H. Bateman, Batheaston, Bath. (Fee £5 5s., returnable.)

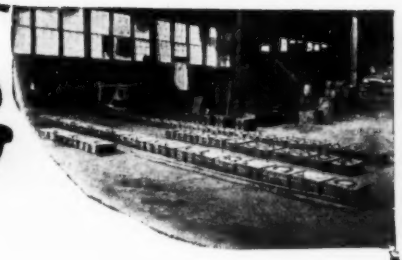
London Founders Visit Sand-Spun Pipe Works.

Last Tuesday, a small party of members of the Metropolitan Section of the Institute of British Foundrymen accepted a cordial invitation from the Staveley Coal & Iron Company to inspect the recently-installed sand-spun pipe foundry near Chesterfield. On arrival at Chesterfield they were met by Mr. T. A. McKenna, of the London office, who accompanied the visitors in a motor-coach to Ringwood Hall, where luncheon was served. Here the guests were met by Mr. Harold Beresford, who presided at table. On arrival at the works the visitors were taken charge of by Mr. Allen (general foundry manager), Mr. Smith and Mr. Duff, who explained in the greatest detail the operation of this unique enterprise. As there was so much to see in a limited time, and the party so small, the individuals each expressed personally their appreciation of the courtesy and hospitality of their hosts.

Iron Salts Cause "Hard Zinc."

Although most recent works on galvanising practice point out the advisability of thoroughly washing the plate after removal from the pickle bath before entering the zinc pot, K. Taussig ("Stahl und Eisen," July 9, 1931) believes that this point deserves special emphasis owing to the erroneous view that iron chloride is volatilised from the galvanising pot. To show that iron salts cause the formation of "hard zinc," he heated commercial zinc containing 0.016 per cent. Fe at 450 deg. C. and from time to time added a mixture of equal parts of iron and ammonium chlorides. After two hours the zinc had assumed the pasty character of "hard zinc" and the iron content of the final metal was found to be 1.75 per cent., while "hard zinc" from a galvanising pot was found to contain about 3 per cent. iron. Diminution of the iron content of the flux layer is not caused by volatilisation of iron chloride, but is due to the reaction forming zinc chloride and metallic iron. Hence the pickled steel must be washed completely free of iron salts and the use of pickle inhibitors is advisable to maintain low iron salt concentration in the pickle liquor.—"Iron Age."

STERLING



ROLLED STEEL

Moulding Boxes

FOR THE MODERN FOUNDRY

Lightness and ease of handling, robust construction, accuracy and durability are the paramount essentials of the modern moulding box.

These qualities are solidly built into all STERLING ROLLED STEEL MOULDING BOXES.

They are made to suit your exact requirements, drilled to suit your existing pattern plates, and fitted with bars when required to conform to your patterns.

Many of the largest and most up-to-date foundries in this Country and Abroad are completely equipped with STERLING BOXES.

WRITE FOR CATALOGUE No. 37.

STERLING FOUNDRY SPECIALTIES LTD.

London Office:
13, VICTORIA STREET, S.W.1.

BEDFORD

Telephone: 3345 BEDFORD.
Telegrams: "STERFLASK, BEDFORD."
Code: WESTERN UNION.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	33	15	0
Three months	34	6	3
Electrolytic	39	0	0
Tough	34	15	0
Best selected	35	0	0
Sheets	70	0	0
India	46	15	0
Wire bars	43	5	0
Do., December	43	5	0
Do., January	43	5	0
Ingot bars	43	5	0
H.C. wire rods	45	0	0
Off. av. cash, Oct.	35	0	1 1/21
Do., 3 mths., Oct.	35	16	10 7/48
Do., Sttlmnt., Oct.	34	19	10 5/11
Do., Electro, Oct.	41	8	10 5/11
Do., B.S., Oct.	37	19	2
Do., wire bars, Oct.	41	17	8 5/11
Solid drawn tubes			10½d.
Brazed tubes			10½d.
Wire			7½d.

BRASS.

Solid drawn tubes	9½d.
Brazed tubes	11½d.
Rods, drawn	8½d.
Rods, extd. or rlld.	5d.
Sheets to 10 w.g.	7½d.
Wire	8d.
Rolled metal	7½d.
Yellow metal rods	5d.
Do. 4 × 4 Squares	6d.
Do. 4 × 3 Sheets	6d.

TIN.

	£	s.	d.
Standard cash	137	2	6
Three months	139	12	6
English	138	15	0
Bars	140	10	0
Straits	139	10	0
Australian	138	5	0
Eastern	140	12	6
Banca (nom.)	149	15	0
Off. av. cash, Oct.	127	0	9 6/11
Do., 3 mths., Oct.	129	16	7 1/11
Do., Sttlmt., Oct.	127	0	2 8/11

SPELTER.

	£	s.	d.
Ordinary	14	0	0
Remelted	12	12	6
Hard	10	15	0
Electro 99.9	16	5	0
English	14	17	6
India	12	15	0
Zinc dust	23	0	0
Zinc ashes	3	15	0
Off. aver., Oct.	12	19	5 23/44
Aver. spot, Oct.	12	14	7 10/11

LEAD.

	£	s.	d.
Soft foreign ppt.	14	15	0
English	16	5	0
Off. average, Oct.	13	4	11 22/44
Average spot, Oct.	13	4	6 8/11

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	24	0	0
Do., V.M. ex-whf.	24	10	0
Rods	30	0	0
Boiler plates			—
Battery plates			—

ANTIMONY.

	£	s.	d.
Special brand, Eng.	40	0	0
Chinese	28	10	0
Crude	20	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver (nom.)	18	0	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£	s.	d.
Ferro-silicon—			
25%	6	17	6
45/50%	10	0	0
75%	16	5	0
Ferro-vanadium—			
35/50%	12/8 lb. Va.		
Ferro-molybdenum—			
70/75% c. free, nominal.			
Ferro-titanium—			
23/25% carbon-free	11d. lb.		
Ferro-phosphorus, 20/25%	£16	0	0
Ferro-tungsten—			
80/85%	1/8½ lb. plus 20%		
Tungsten metal powder—			
98/99%	1/11½ lb. plus 20%		
Ferro-chrome—			
2/4% car.	£34	0	0
4/6% car.	£24	5	0
6/8% car.	£23	0	0
8/10% car.	£22	2	6
Ferro-chrome—			
Max. 2% car.	£34	10	0
Max. 1% car.	£39	15	0
Max. 0.70% car.	£50	5	0
70% carbon-free	11d. lb.		
Nickel—99%	£225 to £230		
Ferro-cobalt	8/3 lb.		
Aluminium 98/99%	£95	0	0
Metallic chromium—			
96/98%	3/- lb.		
Ferro-manganese (net)—			
76/80% loose	£10 15 0 to £11 5 0		
76/80% packed	£11 15 0 to £12 5 0		
76/80% export	(nom.) £ 9 0 0		
Metallic manganese—			
94/96% carbon-free	1/6 lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 7/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel	2	6	0 to	2	7	6
Bundled steel and shrngs.	1	17	6 to	2	6	0
Mixed iron and steel	2	0	0 to	2	3	6
Heavy cast iron	2	7	0 to	2	8	6
Good machinery for foundries				2	12	6
Cleveland—						
Heavy steel				2	2	6
Steel turnings				1	12	6
Cast-iron borings				1	6	0
Heavy forge				3	2	6
W.I. piling scrap				2	15	0
Cast-iron scrap	2	5	6 to	2	7	6
Midlands—						
Light cast-iron scrap				2	0	0
Heavy wrought				2	10	0
Steel turnings, f.o.r.	1	0	0 to	1	2	6
Scotland—						
Heavy steel				2	2	6
Ordinary cast iron				2	7	6
Engineers' turnings				1	10	0
Cast-iron borings				1	11	6
Wrought-iron piling				2	7	0
Heavy machinery				2	15	0

London—Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	30	0	0
Brass	21	0	0
Lead (less usual draft)	12	10	0
Tea lead	9	10	0
Zinc	7	0	0
New aluminium cuttings	62	0	0
Braziery copper	28	0	0
Gunmetal	25	0	0
Hollow pewter	85	0	0
Shaped black pewter	65	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	61/-
Foundry No. 3	58/6
Foundry No. 4	57/6
Forge No. 4	57/-
Hematite No. 1	65/6
Hematite M/Nos.	65/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	73/-
„ d/d Birm.	84/6
Malleable iron d/d Birm.	117/6
Midlands—	
Staffs common*	—
„ No. 4 forge*	61/-
„ No. 3 fdry.*	66/-
Shrops basic	—
„ Cold blast, ord.	—
„ „ roll iron	—
Northants forge*	57/6
„ fdry. No. 3*	62/6
„ fdry. No. 1*	65/6
Derbyshire forge*	61/-
„ fdry. No. 3*	66/-
„ fdry. No. 1*	69/-
„ basic*	—

*d/d Black Country dist.

Scotland—	
Foundry No. 1	72/-
„ No. 3	69/6
Hem. M/Nos. d/d	68/6
Sheffield (d/d district)—	
Derby forge	58/6
„ fdry. No. 3	63/6
Lincs forge	—
„ fdry. No. 3	63/6
E.C. hematite	77/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby forge	62/-
„ fdry. No. 3	67/-
Staffs fdry. No. 3	67/-
Northants fdry. No. 3	65/6
Cleveland fdry. No. 3	67/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	86/6 to 87/-
Clyde, No. 3	86/6 to 87/-
Monkland, No. 3	86/6 to 87/-
Summerlee, No. 3	86/6 to 87/-
Eglinton, No. 3	86/6 to 87/-
Gartsherrie, No. 3	86/6 to 87/-
Shotts, No. 3	86/6 to 87/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

	£	s.	d.	£	s.	d.
Iron—						
Bars (cr.)	9	15	0 to	10	5	0
Nut and bolt iron	8	7	6 to	8	12	6
Hoops	10	10	0 to	12	0	0
Marked bars (Staffs) f.o.t.				12	0	0
Gas strip	10	10	0 to	12	0	0
Bolts and nuts, ¾ in. × 4 in.				12	10	0
Steel—						
Plates, ship, etc.	8	15	0 to	8	17	6
Boiler plts.	8	15	0 to	9	15	0
Chequer plts.				10	7	6
Angles				8	7	6
Tees				9	7	6
Joists				8	15	0
Rounds and squares, 3 in. to 5½ in.				9	7	6
Rounds under 3 in. to ¼ in. (Untested)	6	17	6 & up.			
Flats—8 in. wide and over				8	12	6
„ under 8 in. and over 5 in.				8	17	6
Rails, heavy	8	5	0 to	8	10	0
Fishplates				12	0	0
Hoops (Staffs)				9	10	0
Black sheets, 24g.	8	5	0 to	9	5	0
Galv. cor. shts.	9	2	6 to	9	7	6
Galv. flat sheets	9	12	6 to	9	17	6
Galv. fencing wire, 8g. plain				—		
Billets, soft	5	7	6 to	5	12	6
Billets, hard				6	12	6
Sheet bars	5	0	0 to	5	10	0
Tin bars				5	0	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	10¾d.
Sheet to 10 w.g.	11¾d.
Wire	12⅝d.
Rods	11½d.
Tubes	16½d.
Castings	12½d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
5% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	15.51
No. 2 foundry, Valley	16.00
No. 2 foundry, Birm.	12.00
Basic	16.76
Bessemer	18.26
Malleable	18.26
Grey forge	17.76
Ferro-mang. 80%	85.00
O.-h. rails, h'y, at mill	43.00
Billets	29.00
Sheet bars	29.00
Wire rods	35.00
	Cents.
Iron bars, Phila.	2.09
Steel bars	1.60
Tank plates	1.60
Beams, etc.	1.60
Skelp, grooved steel	1.60
Skelp, sheared steel	1.60
Steel hoops	1.80
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	2.90
Wire nails	1.90
Plain wire	2.20
Barbed wire, galv.	2.55
Tinplates, 100-lb. box	$4.75

COKE (at ovens).

Welsh foundry	20/- to 22/6
„ furnace	15/- to 17/6
Durham and Northumberland—	
„ foundry	15/- to 15/6
„ furnace	15/-
Midlands, foundry	—
„ furnace	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes	20×14	per box	13/9 to 14/3
„	28×20	„	27/6 to 28/6
„	20×10	„	20/3
„	18¾×14	„	14/9
C.W.	20×14	„	12/9 to 13/-
„	28×20	„	25/9
„	20×10	„	19/6
„	18¾×14	„	14/- to 14/3

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6 0 0 to £7 0 0
Bars, hammered, basis	£16 10 0 to £17 0 0
Bars and nail-rods, rolled, basis	£15 17 6 to £16 5 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£32 0 0 to £33 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

TUBES AND FITTINGS.

Current Discounts.

	Tubes.	*Fittings.*
Gas	62½%	57½%
Water ..	58½%	52½%
Steam ..	55%	47½%

W.I. 12½% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
Nov. 19 ..	33	3	9	dec.	48/9
„ 20 ..	33	15	0	inc.	11/3
„ 23 ..	33	16	3	„	1/3
„ 24 ..	33	12	6	dec.	3/9
„ 25 ..	33	15	0	inc.	2/6

Electrolytic Copper.

		£	s.	d.		
Nov. 19 ..	39	10	0	dec.	30/-
„ 20 ..	39	0	0	„	10/-
„ 23 ..	39	0	0	No change	
„ 24 ..	39	0	0	„	„
„ 25 ..	39	0	0	„	„

Standard Tin (cash).

		£	s.	d.		
Nov. 19 ..	131	2	6	dec.	15/-
„ 20 ..	133	5	0	inc.	42/6
„ 23 ..	135	15	0	„	50/-
„ 24 ..	135	15	0	No change	
„ 25 ..	137	2	6	inc.	27/6

Tin (English ingots).

		£	s.	d.		
Nov. 19 ..	132	15	0	dec.	10/-
„ 20 ..	134	15	0	inc.	40/-
„ 23 ..	137	5	0	„	50/-
„ 24 ..	137	5	0	No change	
„ 25 ..	138	15	0	inc.	30/-

Zinc Sheets (English).

		£	s.	d.		
Nov. 19 ..	24	0	0	No change	
„ 20 ..	24	0	0	„	„
„ 23 ..	24	0	0	„	„
„ 24 ..	24	0	0	„	„
„ 25 ..	24	0	0	„	„

Spelter (ordinary).

		£	s.	d.		
Nov. 19 ..	13	15	0	dec.	5/-
„ 20 ..	13	17	6	inc.	2/6
„ 23 ..	14	3	9	„	6/3
„ 24 ..	14	2	6	dec.	1/3
„ 25 ..	14	0	0	„	2/6

Lead (English).

		£	s.	d.		
Nov. 19 ..	16	0	0	dec.	5/-
„ 20 ..	16	0	0	No change	
„ 23 ..	16	5	0	inc.	5/-
„ 24 ..	16	5	0	No change	
„ 25 ..	16	5	0	„	„

AVERAGE MONTHLY PRICES OF STEEL BOILER PLATES IN ENGLAND.

Year.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1895	5 15 0	5 15 0	5 12 6	5 12 6	5 15 0	5 17 6	5 15 0	5 17 6	6 0 0	6 0 0	6 2 6	6 0 0	5 16 10½
1896	6 0 0	6 0 0	6 2 6	6 2 6	6 2 6	6 0 0	6 0 0	6 0 0	6 0 0	6 2 6	6 10 0	6 10 0	6 2 6
1897	6 10 0	6 10 0	6 10 0	6 7 6	6 2 6	6 2 6	6 5 0	6 0 0	6 0 0	6 0 0	6 7 6	6 10 0	6 5 5
1898	6 10 0	6 8 9	6 8 9	6 10 0	6 15 0	6 18 9	6 17 6	6 17 6	7 2 6	6 15 0	7 0 0	7 5 0	6 15 8½
1899	7 5 0	8 0 0	8 2 6	8 2 6	8 5 0	8 5 0	8 12 6	8 12 6	8 15 0	8 15 0	9 2 6	9 5 0	8 17 8½
1900	9 5 0	9 5 0	9 7 6	9 10 0	9 12 6	10 5 0	10 5 0	10 5 0	10 5 0	10 0 0	9 15 0	9 15 0	9 15 10
1901	9 5 0	9 5 0	8 15 0	8 10 0	8 10 0	7 10 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	8 3 11
1902	7 7 6	7 0 0	7 12 6	7 12 6	7 12 6	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 9 7
1903	7 10 0	7 10 0	7 15 0	7 5 0	7 5 0	7 5 0	7 5 0	7 0 0	7 0 0	7 0 0	7 0 0	6 17 6	7 3 11½
1904	6 12 6	6 15 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	6 18 11½
1905	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 10 0	7 5 0	8 0 0	8 0 0	7 1 3
1906	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 10 0	8 0 10
1907	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 0 0	8 0 0	8 8 4
1908	7 10 0	7 10 0	7 10 0	7 5 0	7 5 0	7 5 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 3 9
1909	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	6 15 0	6 15 0	6 15 0	7 0 0	7 0 0	7 0 0	7 0 0	6 18 9
1910	7 0 0	7 0 0	7 1 3	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 10 0	7 10 0	7 10 0	7 5 1
1911	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 14 0	7 10 4
1912	7 18 9	8 0 0	8 0 0	8 7 6	8 10 0	8 10 0	8 10 0	8 15 0	8 16 3	9 0 0	9 2 0	9 5 0	8 11 2½
1913	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	8 19 0	8 15 0	8 5 0	7 15 0	7 15 0	8 17 0
1914	7 15 0	7 15 0	7 15 0	7 13 9	7 10 6	7 5 0	7 0 0	8 0 0	8 2 6	8 5 0	8 5 0	8 5 0	7 15 11½
1915	8 14 0	9 10 0	9 17 6	10 10 0	10 10 0	11 0 0	11 0 0	11 0 0	11 0 0	11 4 0	12 0 0	13 0 0	10 15 5½
1916	13 0 0	13 0 0	13 0 0	12 15 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 12 11
1917	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0
1918	12 10 0	12 10 0	12 10 0	42 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0
1919	13 0 0	15 0 0	15 0 0	15 0 0	19 5 0	19 17 6	21 0 0	21 10 0	21 10 0	21 10 0	21 15 0	23 10 0	18 9 9
1920	26 0 0	28 0 0	28 5 0	28 10 0	29 5 0	30 0 0	30 0 0	30 0 0	30 10 0	31 0 0	31 0 0	31 0 0	29 9 2
1921	30 5 0	29 0 0	25 0 0	25 0 0	25 0 0	23 0 0	21 0 0	20 10 0	19 0 0	17 10 0	16 0 0	14 16 0	22 1 9
1922	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	13 1 8	13 10 0	12 15 0	12 10 0	12 10 0	12 10 0	12 6 0	13 10 9
1923	12 8 9	13 6 0	14 0 0	14 0 0	14 0 0	14 0 0	13 12 6	13 0 0	13 0 0	13 0 0	13 0 0	13 10 0	13 9 1½
1924	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	14 0 0	14 0 0	13 11 0	13 5 0	13 5 0	13 10 11
1925	13 5 0	13 5 0	13 5 0	13 1 0	12 15 0	12 15 0	12 15 0	12 15 0	12 7 6	11 14 0	11 10 0	11 10 0	12 11 5½
1926	11 10 0	11 10 0	11 10 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 6 3
1927	11 5 0	11 5 0	11 5 0	11 5 0	11 2 6	11 0 0	11 0 0	11 0 0	10 16 0	10 10 0	10 10 0	10 10 0	10 19 0½
1928	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0
1929	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 5 0	10 1 3	10 1 3	10 1 3	10 1 7	10 6 8½
1930	10 2 9	10 3 5½	10 3 9	10 3 6	10 2 6	10 2 6	10 2 6	10 2 2½	9 19 6	9 16 3	9 16 3	9 16 3	10 1 6½
1931	9 15 0	9 15 0	9 15 0	9 10 11	9 6 9	9 5 0	9 7 0	9 7 9½	9 8 9	9 5 9	—	—	—

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